Water Commissioner Training

Title 85-5
Montana Code Annotated

Billings, Montana
April 11-12, 2017

Department of Natural Resources
and Conservation (DNRC)

Handouts

- Water Commissioner Training Manual (2016)
- Water Rights in Montana (2014)
- Irrigation Water Measurement (Wyoming Pocket Guide)
- Problem Sets
- "Water" Trivia
- Additional Handouts

Speakers

Mark Elison, Billings Regional Office Manager, DNRC Water Resources Division
Peter Fritsch, Water Master, Montana Water Court
Matt Norberg, Hydrologist, DNRC Water Resources Division
Mike Roberts, Hydrologist, DNRC Water Resources Division

What is a Water Commissioner?

An appointee of the District Court responsible for the measurement and delivery of water based upon the priority of water rights for a specific stream, ditch, reservoir, or other watercourse.

Ditch Rider? Dam Tender? Water Commissioner? Mediator?

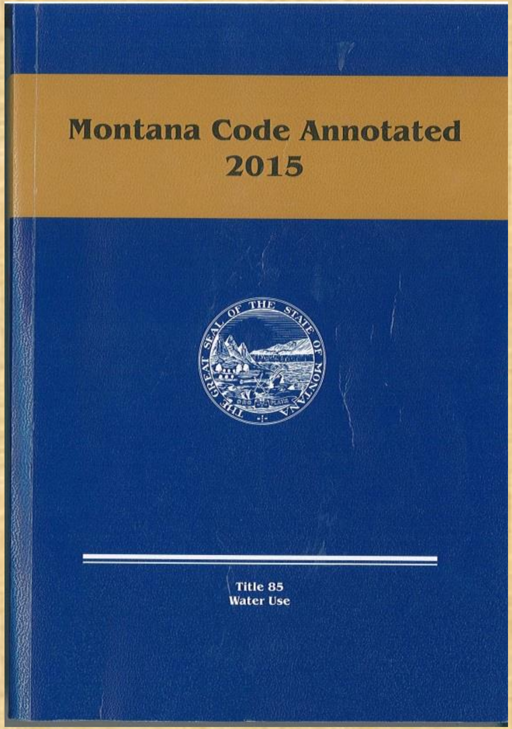
MCA 85-5-101 Applies to any stream, ditch, watercourse, spring, lake, reservoir, or other source of supply which has been determined by a decree of a court of competent jurisdiction (including temporary preliminary, preliminary, and final decrees).

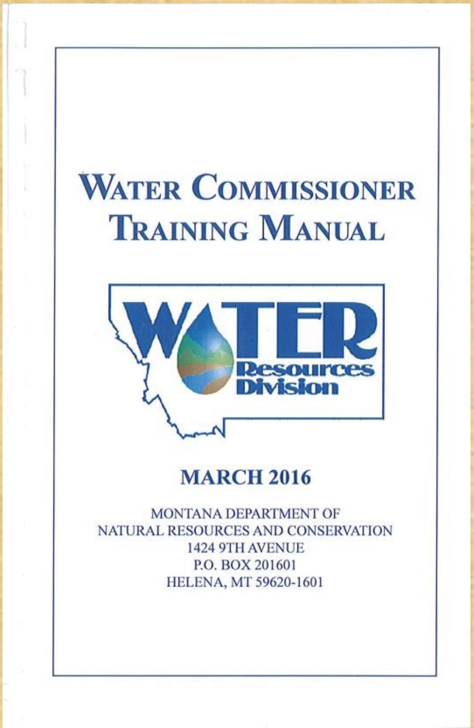
Who are these guys?

Why do we train Water Commissioners?

1989 Montana Legislature

MCA 85-5-111

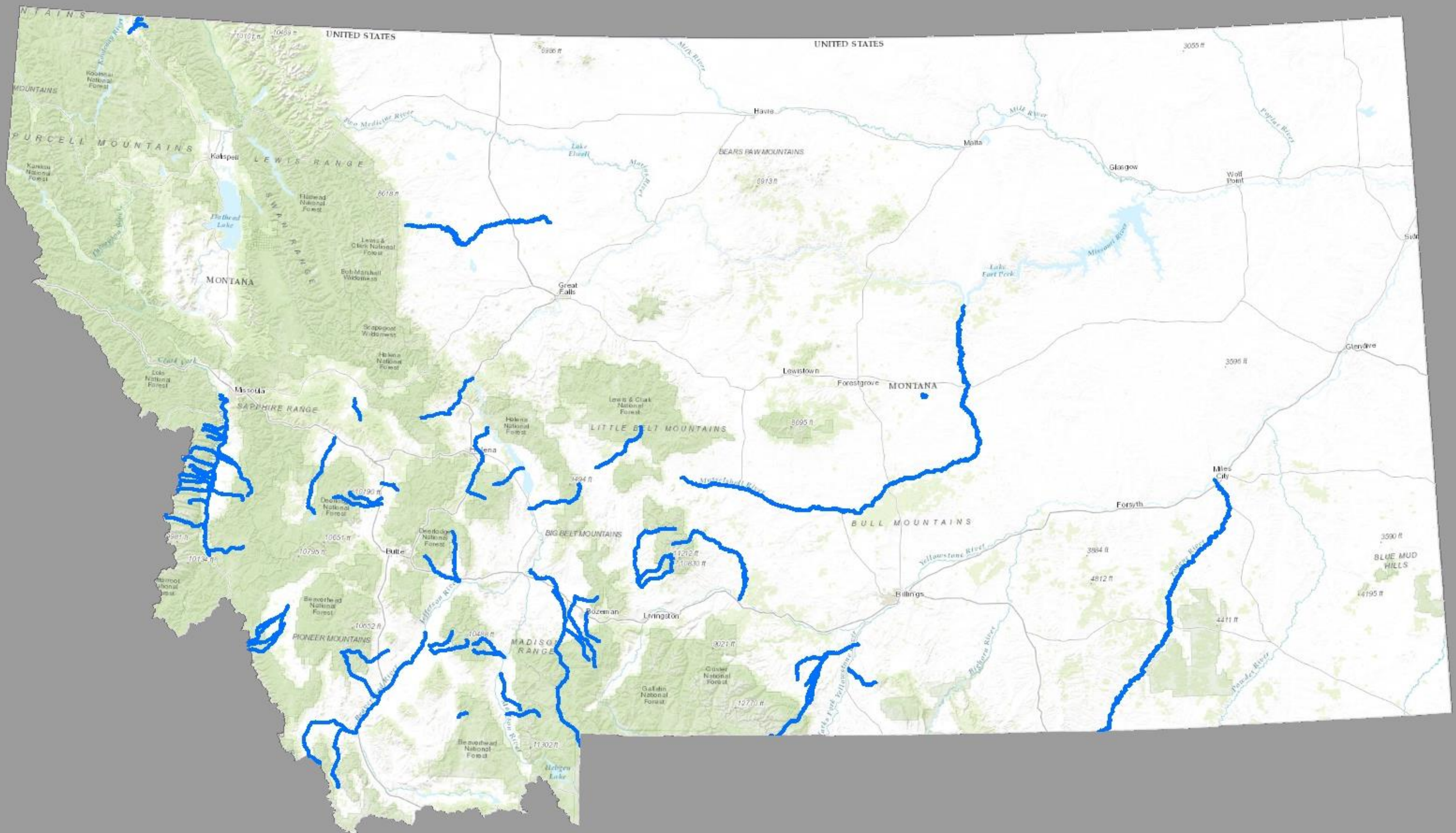




Heightened awareness of water management:

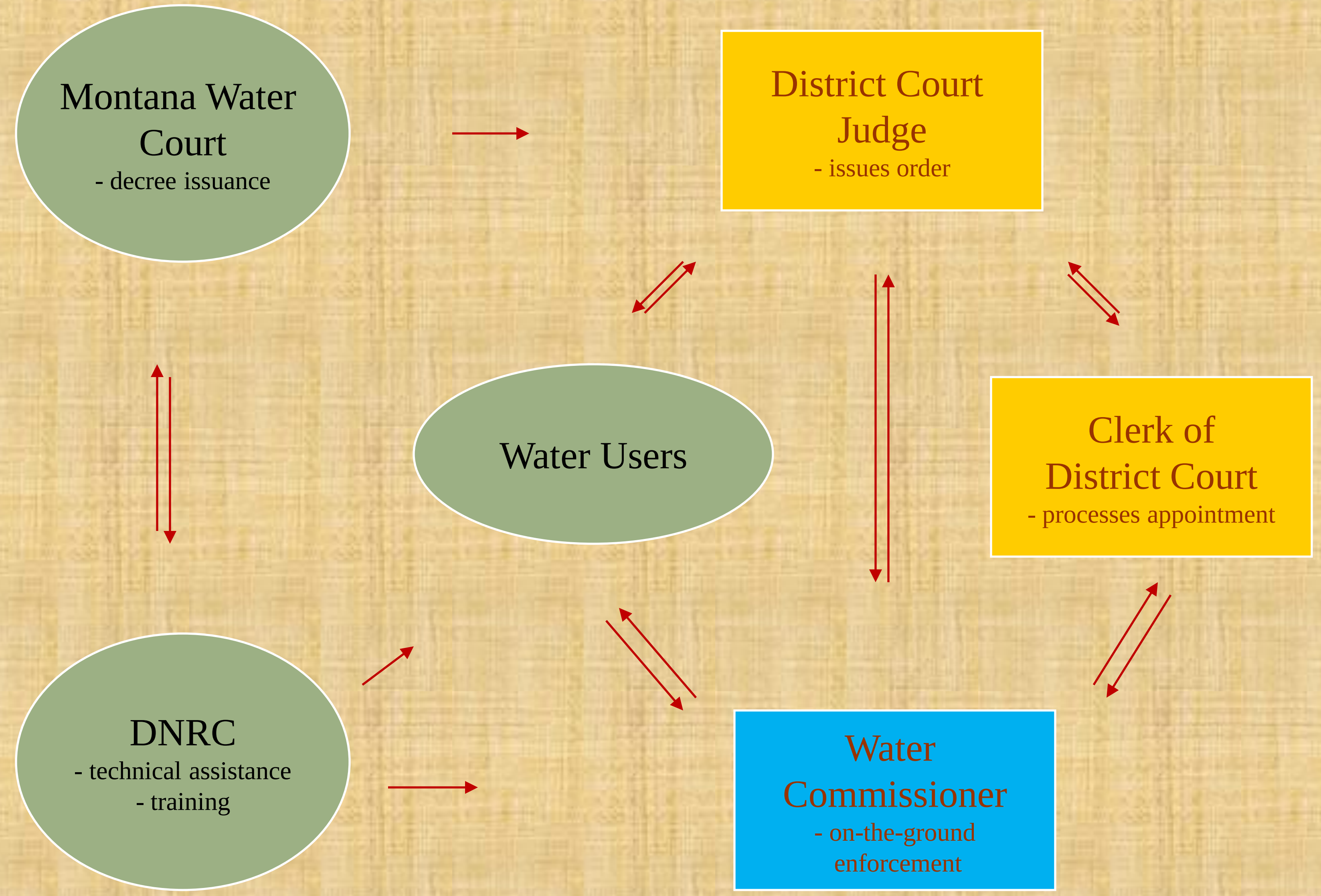
- adjudication – Water Court Decrees
- drought
- water right hearings

Sources With Active Water Commissioners 2015



2016/2017 Appointees: 70 Statewide

Key Players



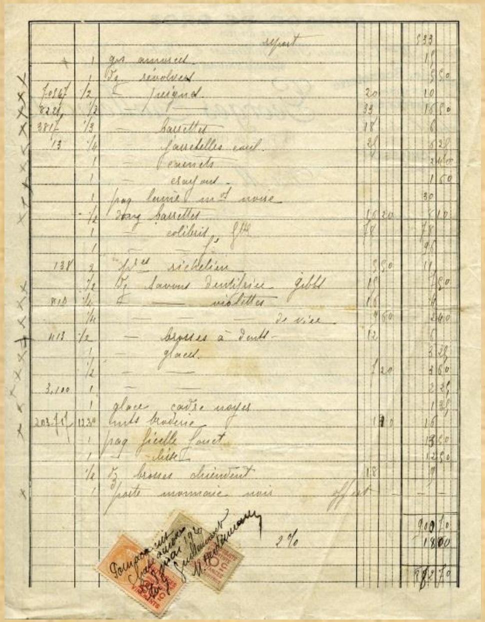
DNRC Examines, Water Court Adjudicates, District Court enforces…..

District Court Decree vs. Water Court Decree

- Typically includes all water rights dated before Decree Issued

- Does not reflect newer water rights, permits, or changes

- Typically includes all water rights, permits, changes in appropriation, and is updated annually.



2014 Priority Date Index - Shields River Enforcement Area

Enforceable Priority Date	Water Right #	Owner	Type	Use	Acres	Pod ID	Means	Qtr Sec	Section	Twp Rge	Source	Enf #	Diversion Name	From - To	Cfs	Total Flow
18800601	43A W 11572 00	PORCUPINE CREEK RANCH INC	USE	ST		1	LS	N2SW	34	5N9E	SHIELDS RIVER	LS010	LS010	01 01 12 31		0.00
18830415	43A W 137659 00	MONTANA, STATE OF BOARD OF LAND COMMISSIONERS	USE	ST		1	DT	NWSENE	25	5N9E	SHIELDS RIVER	018	BECKER DITCH	01 01 12 31		0.00
18830425	43A W 193075 00	BRIGHT, GORDON L	DECR	IR	30.8	1	HG	SENWSW	9	4N9E	SHIELDS RIVER	012	BIG CANAL	05 01 10 04	0.43	0.43
18830425		BRIGHT, JACQUELINE J	DECR	IR	30.8	1	HG	SENWSW	9	4N9E	SHIELDS RIVER	012	BIG CANAL	05 01 10 04		0.43
18830425	43A W 31162 00	ADAMS, DIRK S	DECR	IR	104	1*	HG		4	4N9E	SHIELDS RIVER	012	BIG CANAL	05 15 10 19	3.33	3.76
18830425		ADAMS, DIRK S	DECR	IR	104	2*	HG	NWNWNW	3	4N9E	SHIELDS RIVER	014P	ADAMS PUMP SITE	05 15 10 19		3.76
18830425	43A W 33140 00	ADAMS, DIRK S	DECR	ST		1	LS	SESW	16	4N9E	SHIELDS RIVER	LS006	LS006	01 01 12 31		3.76
18830610	43A W 113381 00	ADAMS, ANITA L	DECR	IR	212	1*	HG	SWSWSE	4	4N9E	SHIELDS RIVER	011	UPPER SWANDAL DITCH	04 15 10 31	1.69	5.45
18830610		ADAMS, ANITA L	DECR	IR	212	2*	HG	SESENW	9	4N9E	SHIELDS RIVER	010	MIDDLE SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, ANITA L	DECR	IR	212	3*	HG	SENWSE	9	4N9E	SHIELDS RIVER	009	LOWER SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, DIRK S	DECR	IR	212	1*	HG	SWSWSE	4	4N9E	SHIELDS RIVER	011	UPPER SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, DIRK S	DECR	IR	212	2*	HG	SESENW	9	4N9E	SHIELDS RIVER	010	MIDDLE SWANDAL DITCH	04 15 10 31		5.45
18830610		ADAMS, DIRK S	DECR	IR	212	3*	HG	SENWSE	9	4N9E	SHIELDS RIVER	009	LOWER SWANDAL DITCH	04 15 10 31		5.45
18830610	43A W 11582 00	PORCUPINE CREEK RANCH INC	DECR	IR	425	1	HG	NWSENE	25	5N9E	SHIELDS RIVER	018	BECKER DITCH	05 15 09 19	0.56	6.01
18830610	43A W 191857 00	ADAMS, ANITA L	USE	ST		1*	DT	SWSWSE	4	4N9E	SHIELDS RIVER	011	UPPER SWANDAL DITCH	01 01 12 31		6.01
18830610		ADAMS, ANITA L	USE	ST		2*	DT	SESENW	9	4N9E	SHIELDS RIVER	010	MIDDLE SWANDAL DITCH	01 01 12 31		6.01
18830610		ADAMS, ANITA L	USE	ST		3*	DT	SENWSE	9	4N9E	SHIELDS RIVER	009	LOWER SWANDAL DITCH	01 01 12 31		6.01

Tuesday, March 11, 2014 Page 1 of 29

How do Water Commissioners Enforce Decrees?

Distribute water by priority date

How do Water Commissioners Enforce Decrees?

Inspect and Adjust Headgates

and

Inspect and Record Measuring Devices

Stored Water Distribution

- Contract water
- Administered separate from natural flows
- May use stream channel as conveyance but must be measured at reservoir outlet (in most cases)

Water Commissioner Appointment

- Petition (15%)
*("owners of at least 15% of water rights" MCA 85-5-101)**

- Order

- Oath of Office

- Bond

***note: House Bill 140 (15% of flow rate)**

Once Appointed, now what??

- notification
- payment system
- worker’s compensation
- training
- list of water users, map, DNRC Tabulation (Red Book), copy of decree


Montana District Courts

MONTANA DNRC

MONTANA JUDICIAL BRANCH

Daily Record of Water Distribution

MONTANA FIFTH JUDICIAL DISTRICT COURT, BEAVERHEAD COUNTY

REPORT OF WATER COMMISSIONER

1

Distributing the waters of ROCK CREEK from MAY 17-06 to JULY 19-06

DATE	Water → Users → MILES	[redacted] Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
MAY 5-17	102	PAPER WORK			DAY — DAY CHARGE + MILES TO DI						
JUNE 6-20	58	CAIL OUT			INVENTORY — CONSULTATIONS						
6-21	58	336	484		185	92	25		0	0	199
22	58	336	484		185	92	25				199
23	—	336	484		185	92	25				199
24	58	336	484		185	92	25				199
25	—	336	484		185	92	25				190
26	58	336	484		185	92	25				124
27	58	222	513		185	0	25				0
28	—	222	513		185		25				
29	58	495	513		185		0				
30	—	495	513		185						No water right
JULY 1	—	495	513		185						
2	—	495	513		185						
3	—	495	513		185						
4	—	495	513		185						
5	58	220	480		0						
6	—	220	480								
7	—	220	480								
8	—	220	480								
9	—	220	480								
10	—	220	480								
11	58	180	320								
12	—	180	320								
13	—	180	320								
14	—	180	320								
15	—	180	320								
16	—	180	320								
17	58	119	194								
18	—	119	194								
19	—	119	194		0	0	0		0	0	0
TOTAL											

Commissioner expenses:

Daily wage: $ 75 00 per day for 13 days.......................................$ 975.0

Mileage: $ 0.45 per mile for 798 miles.......................................$ 359.1

Workers Compensation insurance, payment made during current month........................ $

Total water commissioner expense for the month.. $

SUBMITTED this 28 day of JULY, 2006

Water Commissioner

DAYS LISTED WITH MILEAGE ARE DAYS WORKED

Daily allotment (inches)

Payment (wage and mileage)

Water Commissioner Report

Judicial District #_____ County____________Clerk of Court__________________
Water Commissioner____________________Water Body__________________

July	Water User	Smith	Smith	Jones	Davis	Williams	Williams
2017	Ditch	Big	Middle	Small	Pasture	Farm1	Farm2
DATE	MILES	Inches	Inches	Inches	Inches	Inches	Inches
7/1	45	40	40	80	160	60	20
7/2	45	40	40	80	160	60	20
7/3		40	40	80	160	60	20
7/4		40	40	80	160	60	20
7/5		40	40	80	160	60	20
7/6		40	40	80	160	60	20
7/7		40	40	80	160	60	20
7/8		40	40	80	160	60	20
7/9		40	40	80	160	60	20
7/10	45	25	80	120	160	60	20
7/11	45	25	80	120	160	60	20
7/12		25	80	120	160	60	20
7/13		25	80	120	160	60	20
7/14		25	80	120	160	60	20
7/15		25	80	120	160	60	20
7/16	75	25	80	120	160	60	20
7/17	45	25	80	120	160	60	20
7/18		0	80	0	160	60	20
7/19		0	80	0	160	60	20
7/20		0	80	0	160	60	20
7/21		0	80	0	160	60	20
7/22	75	0	80	0	160	60	20
7/23	75	0	80	0	160	60	20
7/24		0	80	0	80	0	20
7/25		0	80	0	80	0	20
7/26		0	80	0	80	0	20
7/27		0	20	0	80	0	20
7/28	45	0	20	0	80	0	20
7/29	45	0	20	0	80	0	20
7/30		0	20	0	80	0	20
7/31		0	20	0	80	0	20
TOTAL	540	560	1820	1680	4320	1380	620

Commissioner Expenses:							
Daily Wage:	100	per day	10	days		$	1000
Mileage:	0.75	per mile	540	miles		$	405
Workers Comp:	281.81	per month				$	281.81
Other Expenses (list):			phone, log books			$	100
Total Commissioner Expenses for the month						**$**	**1787**

Water Commissioner Report

Monthly Billing Summary

Water User	Total Inches	Percent of Total	Monthly Bill		Annual Bill to Date
Smith	560	7%	$119.40		
Smith	1820	22%	$388.07		
Jones	1680	20%	$358.21		
Davis	4320	52%	$921.12		
Williams	1380	16%	$294.25		
Williams	620	7%	$132.20		

Comments:

SUBMITTED the ____ day of ____ 20__

WATER COMMISSIONER DASHBOARD

HELP:
CLICK THIS BUTTON FOR HELP AND CONTACT INFORMATION

Step 1:
Enter Information into the cells below

Montana Judical Court	
County	
Name	
Water Source Name	
Workers Compensation Amount	
Wage	
Are you paid per day, month or season?	

Step 2:
Enter how much water you distributed for the appropriate month. Click the button below to navigate to data entry for that month.

- April
- May
- June
- July
- August
- September
- October

Step 3:
View a summary of your expenses and billings here

Monthly Billing Summary

- April
- May
- June
- July
- August
- September
- October

Monthly Expense

- April
- May
- June
- July
- August
- September
- October

STREAM COMMISSIONER DASHBOARD

DATA ENTRY | MONTHLY EXPENSES SUMMARY | MONTHLY BILLING SUMMARY | ANNUAL SUMMARIES

Montana Judicial Court:
County:
Commissioner Name:

	USER DITCH	MILLIE COOL	MIKE DRY	JAMIE WET	JENN ARID	SHARLA WET	MIKE WET	JOHN WET
Date	MILES	INCHES	INCHES	INCHES	INCHES	INCHES	INCHES	INCHES
7/1/2016	45	13	40	15	10	10	15	5
7/2/2016		13	40	15	10	10	15	5
7/3/2016		13	40	15	10	10	15	5
7/4/2016		13	40	15	10	10	15	5
7/5/2016	50	25	40	15	10	10	15	5
7/6/2016		25	40	15	10	10	15	5
7/7/2016		25	40	15	10	10	15	5
7/8/2016		25	40	15	10	10	15	5
7/9/2016	60	25	80	15	10	10	15	5
7/10/2016		25	80	15	10	10	15	5
7/11/2016		25	80	15	10	10	15	5
7/12/2016		25	80	15	10	10	15	5
7/13/2016	45	25	80	15	0	10	15	5
7/14/2016		25	80	15	0	10	15	5
7/15/2016		25	80	15	0	10	15	5
7/16/2016		25	80	15	0	10	15	5
7/17/2016	56	25	80	15	0	10	0	0
7/18/2016		25	80	15	0	10	0	0
7/19/2016		25	80	15	0	10	0	0
######		25	80	15	0	10	0	0
7/21/2016		25	80	15	0	10	0	0
######	56	0	20	15	0	10	0	0
######		0	20	15	0	10	0	0
######		0	20	15	0	10	0	0
7/25/2016		0	20	15	0	10	0	0
######	34	0	20	15	0	10	0	0
7/27/2016		0	20	15	0	10	0	0
######		0	20	15	0	10	0	0
######		0	20	15	0	10	0	0
######	5	0	20	15	0	10	0	0
7/31/2016		0	20	15	0	10	0	0
Total	351	477	1560	465	120	310	240	80

$$$ Payment

- Proportionate (mileage, training, worker's comp, ect)

- Payment system (MCA 85-5-204, 2007) Receive up to 80% money up front.

- Water Commissioner is paid directly through Clerk of Courts office

- If user does not pay, water can be shut off (MCA 85-5-206)

MONTANA STATEFUND

855 Front Street - P.O. Box 4759 - Helena, MT 59604-4759
Customer Service: 800-332-6102 or 406-495-5000
Fax 406-495-5020 - TDD/TTY 406-495-5030
Fraud Hotline: 888-682-7463 (888-MT-CRIME)
www.montanastatefund.com

WORKERS COM ARRANGEMENT FOR WATER COMMISSIONERS
07/1/2016 *

1. Term: Two options:
   a. Short term: Policy will only run for the period requested for coverage for the water commissioner. Policy will cancel and not renew & if commissioner is appointed for another period, a new application will have to be completed & submitted.
   b. Regular 12 month term: Policy will run for 12 months with coverage for the water commissioner being only for the months given. The application needs to be specific on the time frame required for coverage on the owner of the policy. The policy will automatically renew in 12 months as long as payrolls & payments are kept up to date.

2. Binding Effective date: This will be the day following the date when 3 items have been received in MSF office:
   a. Any prior policy reconciled (payroll reports received & payment received) if applicable.
   b. Completed application.
   c. Deposit & expense constant or 1st installment.

3. Coverage for water commissioner: The covered period will be from no sooner than the effective date of the policy (can use a later date) to the last date the commissioner thinks he/she will need coverage. Ex: policy starts 06/01/2014 & coverage is needed from 06/01/2014 to the end of Oct. So the last day of coverage would be 10/31/2014. ***If the commissioner stops earlier, it is his/her responsibility to contact MSF to request the coverage stop sooner. If the coverage is needed longer again it is the responsibility of the commissioner to notify MSF PRIOR to ending coverage date for an extension.***

4. The 2 options of policies:
   a. Installment method:
      i. This will require a payment of at least **$416.80** down (includes the expense constant) & 2 more monthly payments to pay off the premium in advance. Usually has an annual payroll reporting frequency.
   b. Deposit method:
      i. This will require the payment of the expense constant plus a 20% of the estimated premium.
      ii. The payroll reporting will be semi-annually, meaning a payroll report will be sent July & Jan. They have to be filled out & returned by due date & premium due will need to be paid by due date. These payrolls will be due the end of July & the end of Jan with the premium due the following months.

The rates for the water commissioners this year will be:
$8.33/PER $100.

The lowest wage that commissioners can elect is $900/month for sole proprietors. The approximate premium cost would be **$484.30** to bind coverage and 2 monthly installments of **$309.30** which would **be *prorated when coverage is removed or cancelled as stated above.*** Other options may be considered.

Your contacts are **Rabecca Lindal** 5260 and **Karen Beddow 5112** 1-800-332-6102. Both of these customer service specialists will be able to assist you with any questions.

**note: 2016 adjustments are bolded. Changes made on 5/032016 by DNRC per email contact with Rabecca Lindal from Montana State Fund.*

note: **07/01/2016 Rates **change** any application received after 07/01/2015 will be subject to new rates & binding amount.*

Through July 1, 2017 (MCA 85-5-101(7))

Document

- ➢ date and time of anything you do
- ➢ daily record of water distribution
- ➢ mileage
- ➢ any repairs (photo document, date)
- ➢correspondence with users, Judge, DNRC, Water Court
- ➢ worker's compensation insurance

Tools: shovel, hand level, maps, field book, cell phone, reference materials, field notebook

Water Commissioners Will:

- Measure and Distribute water based on priority and decree.
- Inspect Headgates and Measuring devices.
- Record daily distribution.
- Shut water off based on:
  > priority
  > lack of payment
  > non-cooperation regarding infrastructure

Water Commissioners Cannot

- Change PODs, change periods of use, flow rates, place of use, or priority dates.
- Deliver water based on use
- Deliver water to non-water right holders
- Deliver water outside of priority*
- Be exempt from 310 permitting

(National Streambed and Preservation Act)

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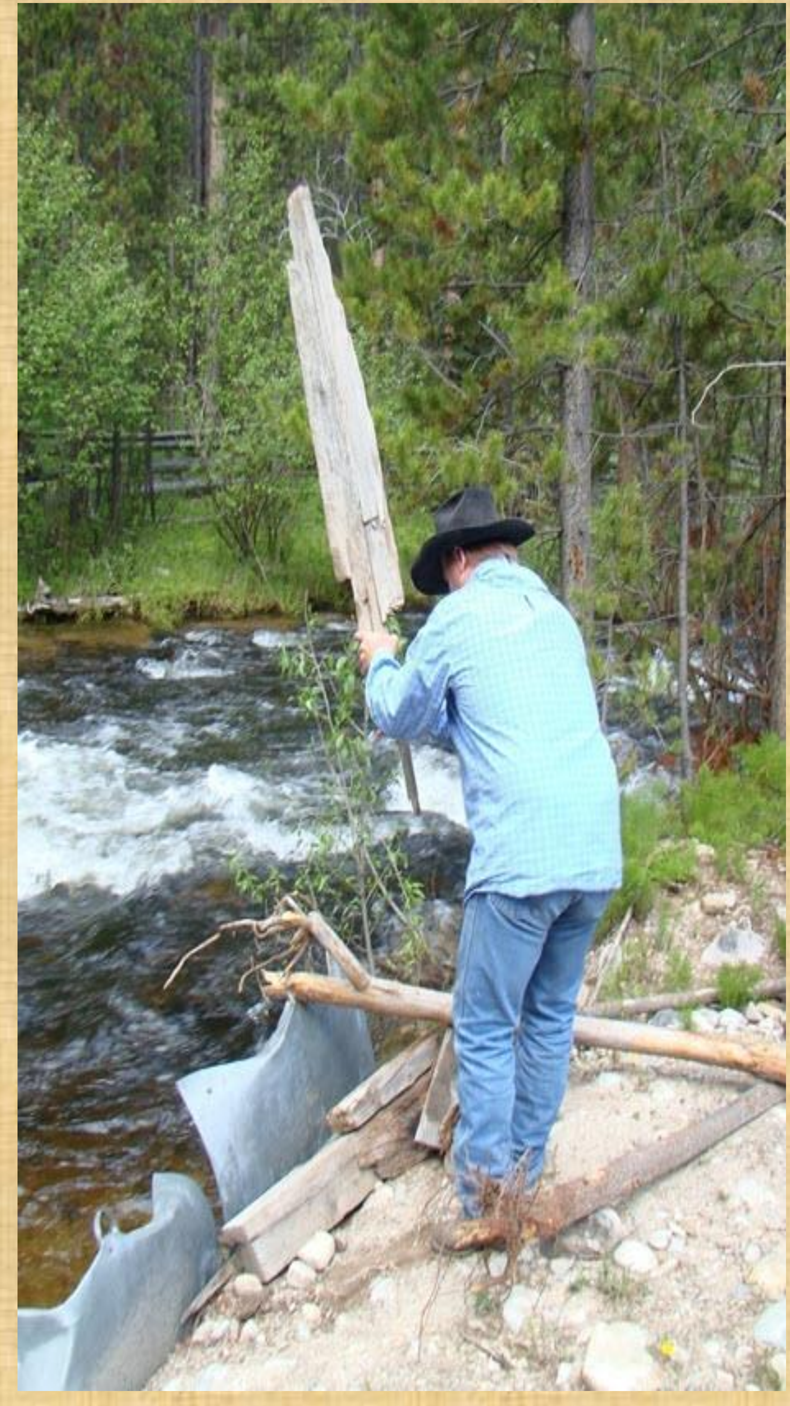
(National Streambed and Preservation Act)

Rights and Duties of Water Users:

- Required to have suitable and functioning headgate and measuring device.
- May file dissatisfied user complaint with judge.
- Failure of Water Commissioner to perform duty is Contempt of Court.



Interference With Actions of a Commissioner

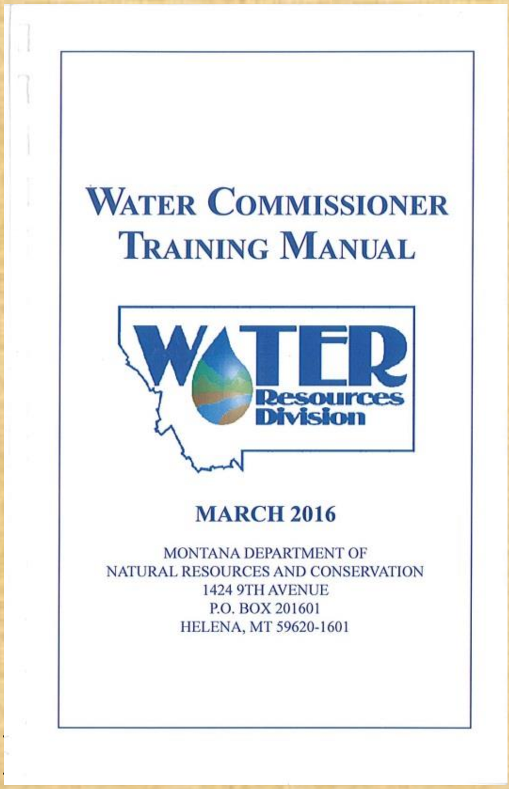
MCA 85-5-406. A person opening or closing a headgate after being set by the commissioner or who in any manner interferes with the commissioner in the discharge of the commissioner's duties is guilty of contempt of court and may be proceeded against for contempt of court as provided in contempt cases.

Steep Learning Curve

Requires Patience of both Water Commissioner and Water User

Special Circumstances

- water rights not in decree
- carriage water
- temporary changes
- road construction
- instream flow/lease enforceme
- return flow
- seepage rights
- futile call (Teton Prairie decision)



Communication

Water User and Water Commissioner   Water Commissioner and District Court

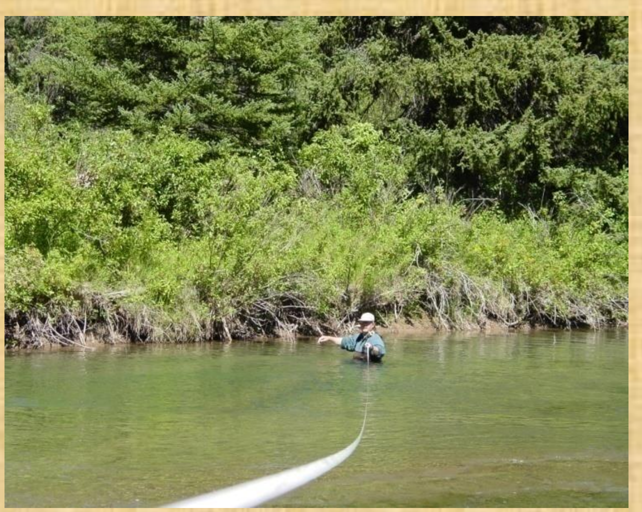
Issues that require Communication include:

- Turning on/off
- Headgate Adjustment
- Access
- Repair/Replacement
- Payment Issues

Water Mediation Training

MCA 85-5-110
MCA 85-5-111

Take Precautions




Safety First


Boil
Backwash
Low-Head
Dam
Escape Route

Basin Snowpack

2017

MONTANA SNOTEL Snow Water Equivalent Update Graph

As of THURSDAY: APRIL 6 , 2017

Basin	Snow Water Equivalent Percent of Median
KOOTENAI RIVER BASIN	103%
FLATHEAD RIVER BASIN	108%
UPPER CLARK FORK RIVER BASIN	96%
BITTERROOT RIVER BASIN	105%
LOWER CLARK FORK RIVER BASIN	104%
JEFFERSON RIVER BASIN	95%
MADISON RIVER BASIN	105%
GALLATIN RIVER BASIN	91%
MISSOURI HEADWATERS	96%
HEADWATERS MISSOURI MAINSTEM	84%
SMITH, JUDITH, AND MUSSELSHELL RIVER BASINS	70%
SUN, TETON AND MARIAS RIVER BASINS	114%
MISSOURI MAINSTEM RIVER BASIN	86%
ST MARY AND MILK RIVER BASINS	111%
UPPER YELLOWSTONE RIVER BASIN	118%
WIND RIVER BASIN (WYOMING)	194%
SHOSHONE RIVER BASIN (WYOMING)	146%
BIGHORN RIVER BASIN (WYOMING)	132%
TONGUE RIVER BASIN (WYOMING)	117%
POWDER RIVER BASIN (WYOMING)	100%
LOWER YELLOWSTONE RIVER BASIN	146%

Legend:	<70%	70-90%	91-110%	111-130%	>130%

* = Data are not available or data may not provide a valid measure of conditions for over half of the sites within the basin.

2016

MONTANA SNOTEL Snow Water Equivalent Update Graph

As of WEDNESDAY: APRIL 6 , 2016

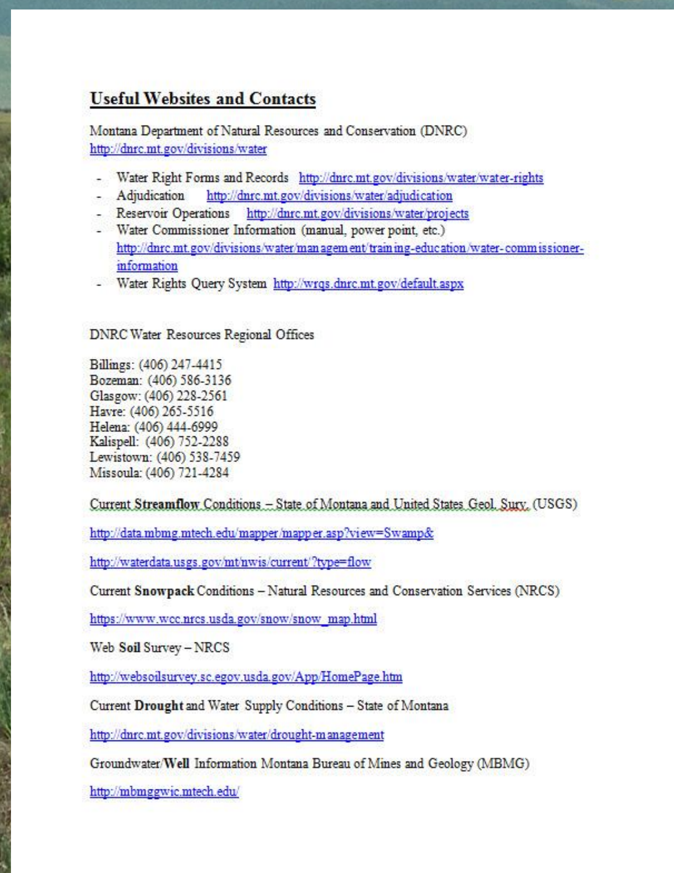
Basin	Snow Water Equivalent Percent of Median
KOOTENAI RIVER BASIN	98%
FLATHEAD RIVER BASIN	97%
UPPER CLARK FORK RIVER BASIN	95%
BITTERROOT RIVER BASIN	96%
LOWER CLARK FORK RIVER BASIN	88%
JEFFERSON RIVER BASIN	107%
MADISON RIVER BASIN	98%
GALLATIN RIVER BASIN	99%
MISSOURI HEADWATERS	102%
HEADWATERS MISSOURI MAINSTEM	95%
SMITH, JUDITH, AND MUSSELSHELL RIVER BASINS	108%
SUN, TETON AND MARIAS RIVER BASINS	53%
MISSOURI MAINSTEM RIVER BASIN	90%
ST MARY AND MILK RIVER BASINS	80%
UPPER YELLOWSTONE RIVER BASIN	93%
WIND RIVER BASIN (WYOMING)	102%
SHOSHONE RIVER BASIN (WYOMING)	94%
BIGHORN RIVER BASIN (WYOMING)	90%
TONGUE RIVER BASIN (WYOMING)	74%
POWDER RIVER BASIN (WYOMING)	90%
LOWER YELLOWSTONE RIVER BASIN	92%

Legend:	<70%	70-90%	91-110%	111-130%	>130%

* = Data are not available or data may not provide a valid measure of conditions for over half of the sites within the basin.

Tools/Websites

DNRC Water Commissioner Website
Water Rights Query System
Adjudication Page
USGS Streamflows
NRCS Snowpack
Web Soil Survey



Useful Websites and Contacts

Montana Department of Natural Resources and Conservation (DNRC)
http://dnrc.mt.gov/divisions/water

- Water Right Forms and Records http://dnrc.mt.gov/divisions/water/water-rights
- Adjudication http://dnrc.mt.gov/divisions/water/adjudication
- Reservoir Operations http://dnrc.mt.gov/divisions/water/projects
- Water Commissioner Information (manual, power point, etc.) http://dnrc.mt.gov/divisions/water/management/training-education/water-commissioner-information
- Water Rights Query System http://wrqs.dnrc.mt.gov/default.aspx

DNRC Water Resources Regional Offices

Billings: (406) 247-4415
Bozeman: (406) 586-3136
Glasgow: (406) 228-2561
Havre: (406) 265-5516
Helena: (406) 444-6999
Kalispell: (406) 752-2288
Lewistown: (406) 538-7459
Missoula: (406) 721-4284

Current **Streamflow** Conditions – State of Montana and United States Geol. Surv. (USGS)

http://data.mbmg.mtech.edu/mapper/mapper.asp?view=Swamp&

http://waterdata.usgs.gov/mt/nwis/current/?type=flow

Current **Snowpack** Conditions – Natural Resources and Conservation Services (NRCS)

https://www.wcc.nrcs.usda.gov/snow/snow_map.html

Web **Soil** Survey – NRCS

http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

Current **Drought** and Water Supply Conditions – State of Montana

http://dnrc.mt.gov/divisions/water/drought-management

Groundwater/**Well** Information Montana Bureau of Mines and Geology (MBMG)

http://mbmggwic.mtech.edu/

Montana DNRC State Water Projects Bureau Reservoirs

MONTANA DNRC

MT DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

STREAM GAGE PROGRAM

Montana Department of Natural Resources
and Conservation
Water Management Bureau

Legislation and other Legal Decisions

HB 110 (Hamlett) : Supplemental Preliminary Decrees, exempt wells

Requires exempt filings that are not filed to file to get standing in a decree. Description of fiscal impact: This bill provides for the issuance of a supplemental preliminary decree in basins where a preliminary decree, related to exempt claims, has been issued prior to July 1, 2019. The bill also sets forth notification standards related to the issuance of supplemental preliminary decrees.

HB 124 (Stewart-Peregoy) : Requires Water Commissioner Training

HB140 (Stewart-Peregoy) : Includes 15% of flow rate for petition appointment

Teton Prairie Decision (Steven Kelly, Monte Geise, Henry Nagamori and Kalanick Ranch Inc. vs. Teton Prairie, LLC) : Futile Call

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Passed House

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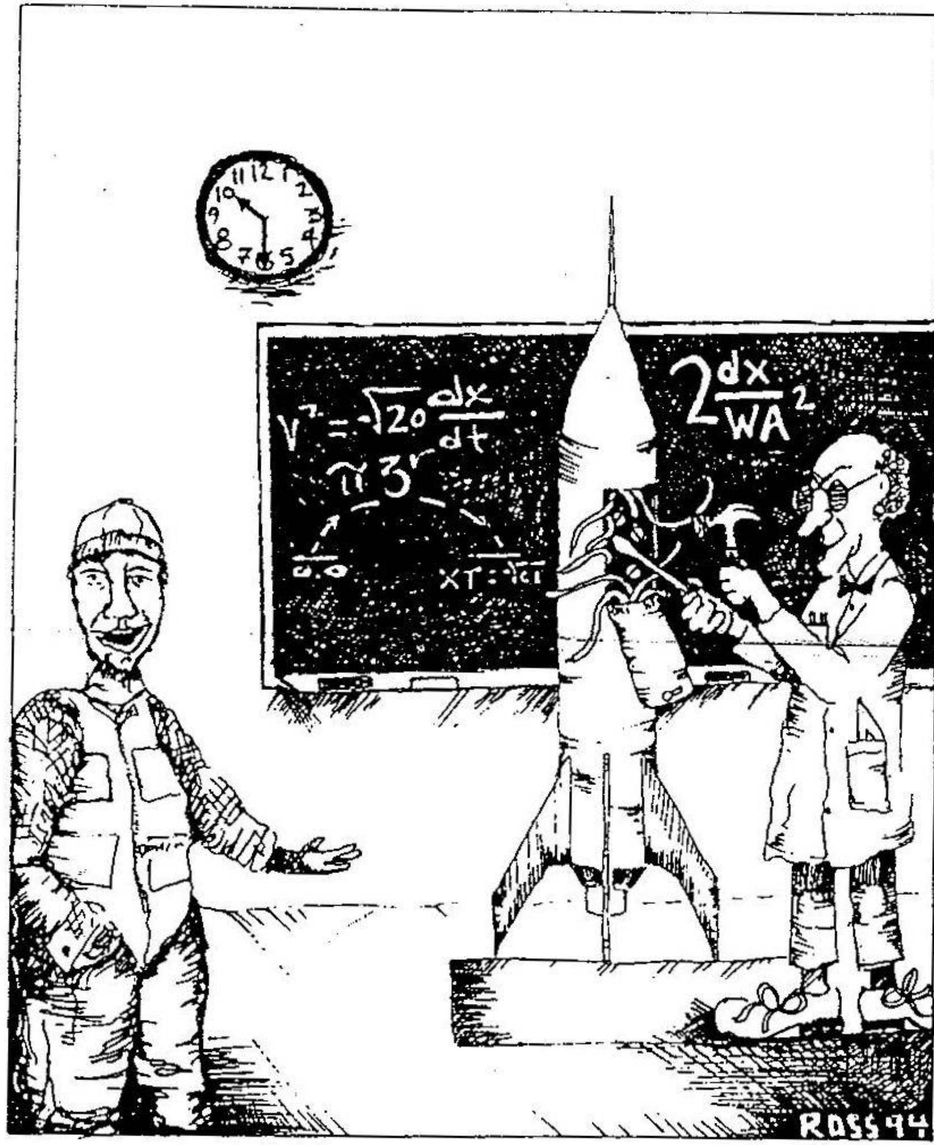

"C'mon, it can't be that difficult.
This isn't Water Distribution you know"

"Water" Trivia Questions

1) List the following rivers longest to shortest: Kootenai River, Yellowstone River, Milk River

2) Which one of these stream names is made up? a) Bloody Dick Creek, b) Russian Bill Creek, c) Dry Stinky Creek, d) Killem Quick Creek, e) Cattle Queen Creek, f) Big Foot Creek g) none of the above

3) What three rivers join together to form the Missouri River at Three Forks?

4) How many bones did Butte daredevil Evel Knievel fracture in his career?
a) 0 b) 52 c) 107 d) 433

5) What approximate percent of precipitation that falls in the Missouri watershed flows out of Montana? a) 0 b) 20 c) 50 d) 100

6) Name at least three out of six of these famous Montanans.






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Milk – Yellowstone - Kootenai

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Dana Carvey


Andrew Garcia


Gary Cooper

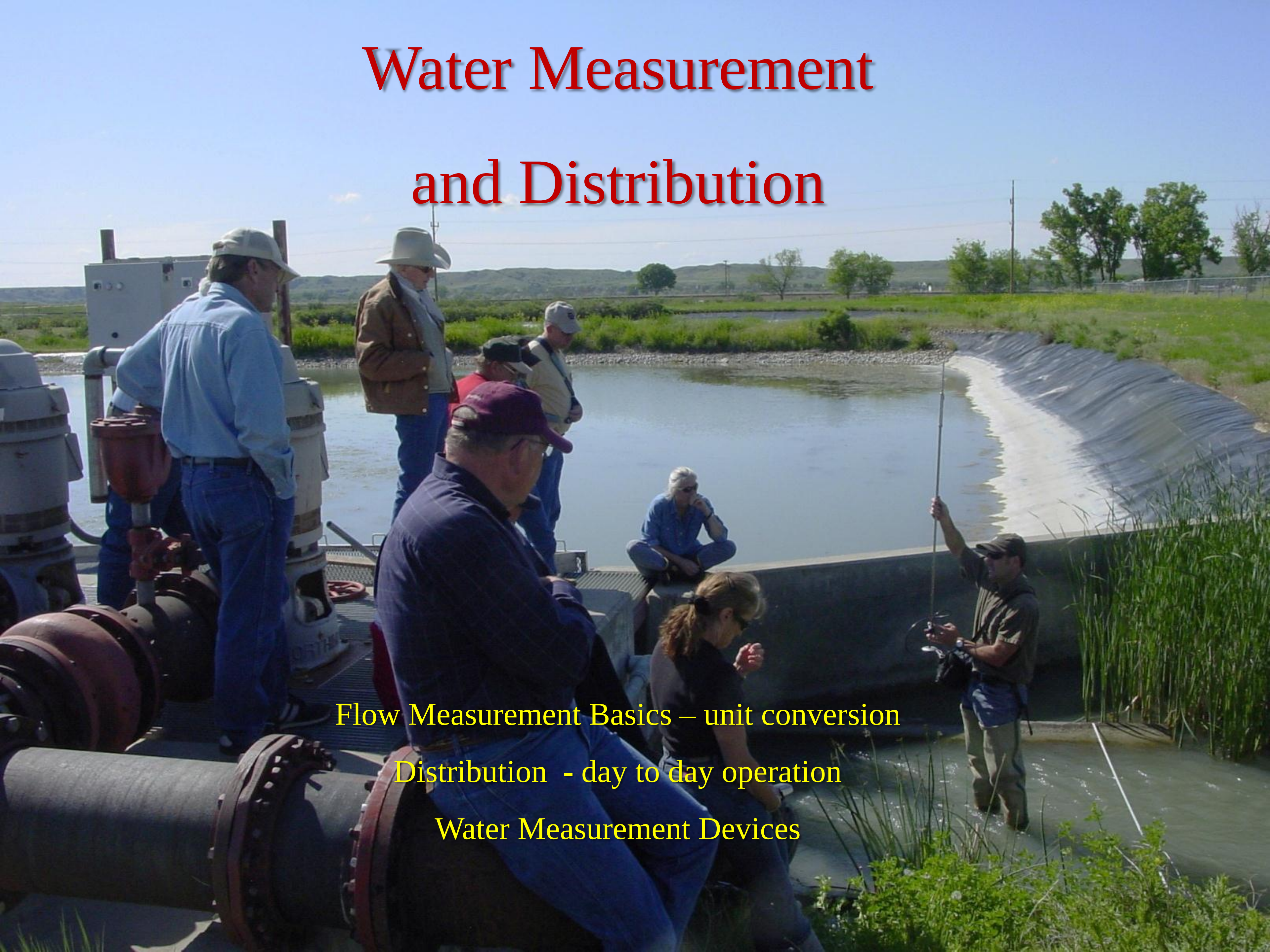
Sen. John Tester


Stan Lynde


Phil Jackson


Water Measurement

and Distribution



Flow Measurement Basics – unit conversion

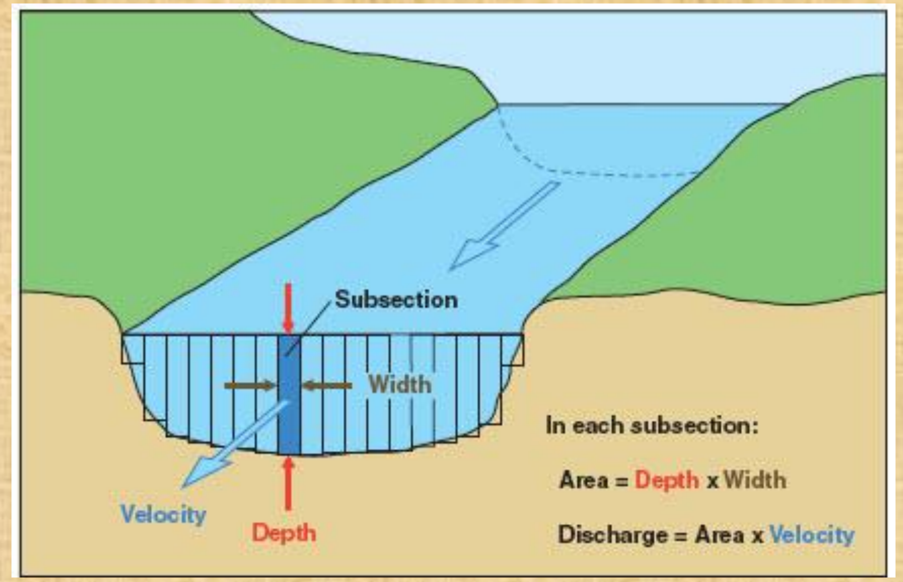
Distribution - day to day operation

Water Measurement Devices

Flow Measurement Basics

- Flow Rate or discharge is the volume of water passing a flow section per unit time

- Standard units of ***cubic feet per second*** (cfs)



Flow Measurement Basics

- Flow Rate or discharge is the volume of water passing a flow section per unit time

- Standard units of ***cubic feet per second*** (cfs)

1 cfs is equivalent to:

40 miner's inches in Montana
448.8 gallons per minute (gpm)
1.98 ac-ft per day

Flow Measurement Basics

- Basic flow equation
  - Flow Rate (discharge) = Area · Velocity
  - Q = A · V

$$30\,ft^2 \bullet 3\frac{ft}{\sec} = ?$$

Flow Measurement Basics

- Basic flow equation
  - Flow Rate (discharge) = Area · Velocity
  - $Q = A \cdot V$

$$30\, ft^2 \bullet 3 \frac{ft}{\sec} = ?$$

$90\ ft^3/sec$
or
90 cfs

Flow Measurement Basics

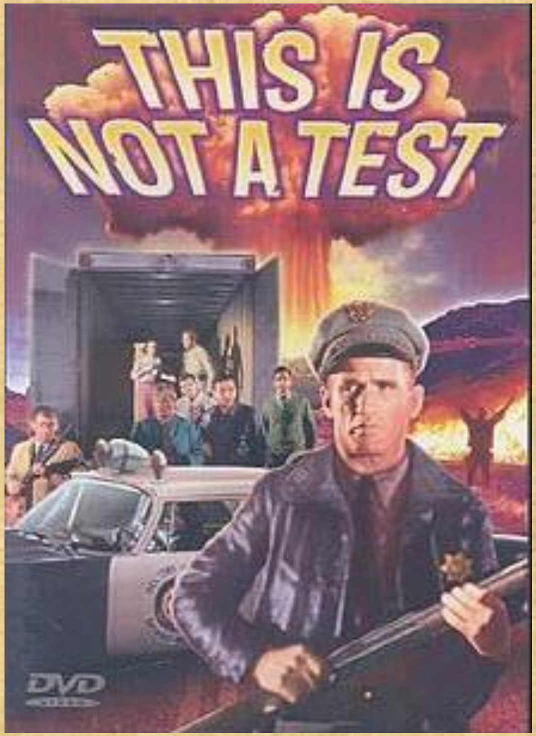
- Volume Units
  - Standard unit of volume is acre-feet (ac-ft)
  - An ac-ft is equivalent to a foot of water on one acre.

1 ac-ft is equivalent to: 325,851 gallons

43,560 cubic feet

Flow Measurement Basics

Example Problems



WCT Manual: inside cover
or page 55

Based on the District Court decree, an irrigator has the right to divert 140 inches of water.

1) What is their water right in cubic feet per second (cfs)?

2) Convert their water right to gallons per minute (gpm).

3) Convert to gallons per day (gpd).

4) How many acre-feet (af) is the irrigator entitled to in 10 days?

A different irrigator is entitled to 400 acre-feet over a period of 20 days. Assuming irrigation is non-stop, what is their flow rate in cfs?

1 cfs = 40 m.i.
1 cfs = 448.8 gpm
1 cfs for 24 hrs = 1.983 acre-feet

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140 in. / 40 in. = 3.5 cfs

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1570.8 gpm * 60 min/hr * 24 hr/day = 2.26 million gallons

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3.5 cfs * 1.986 acre-feet/cfs * 10 days = 69.5 acre feet

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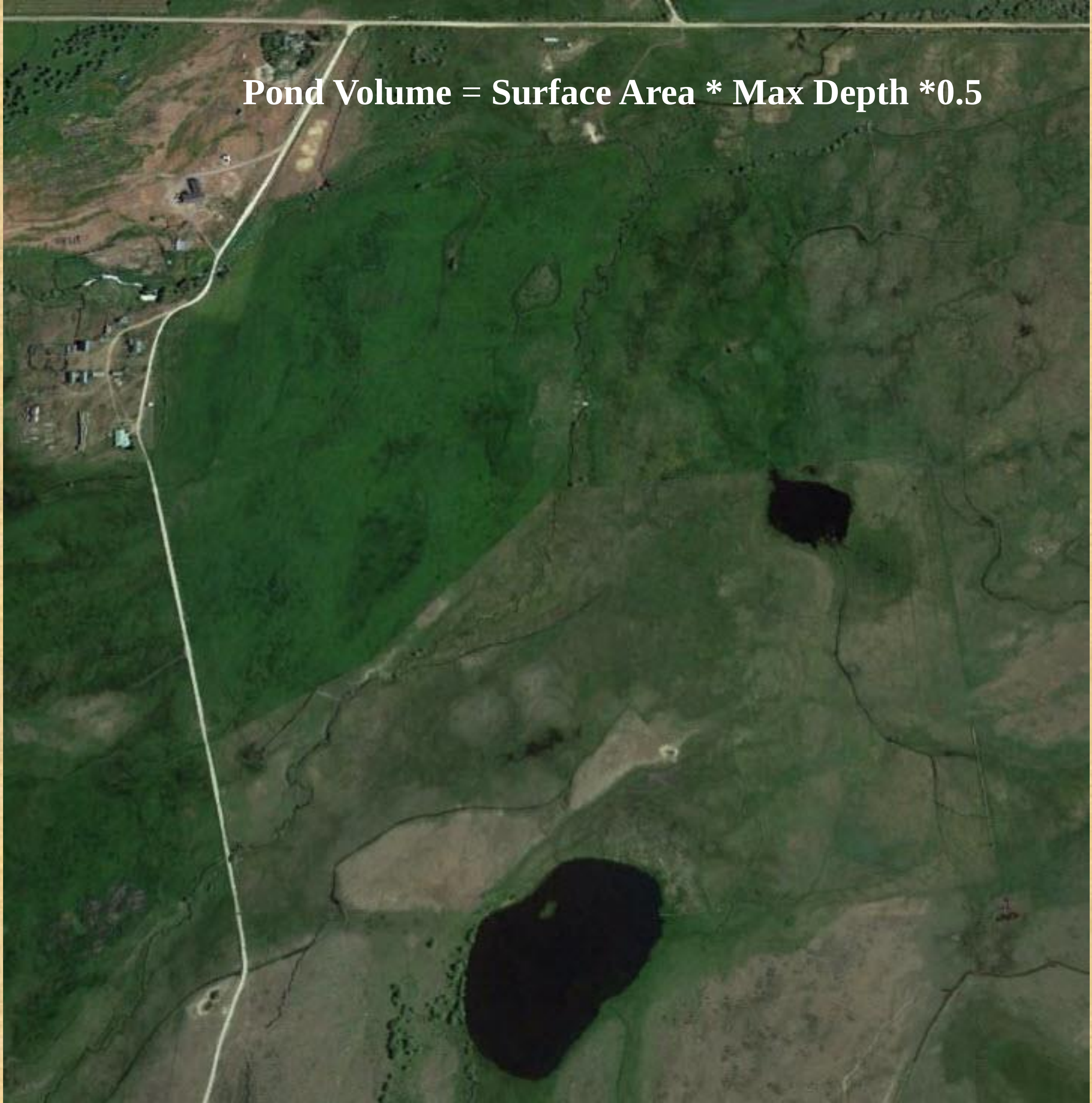
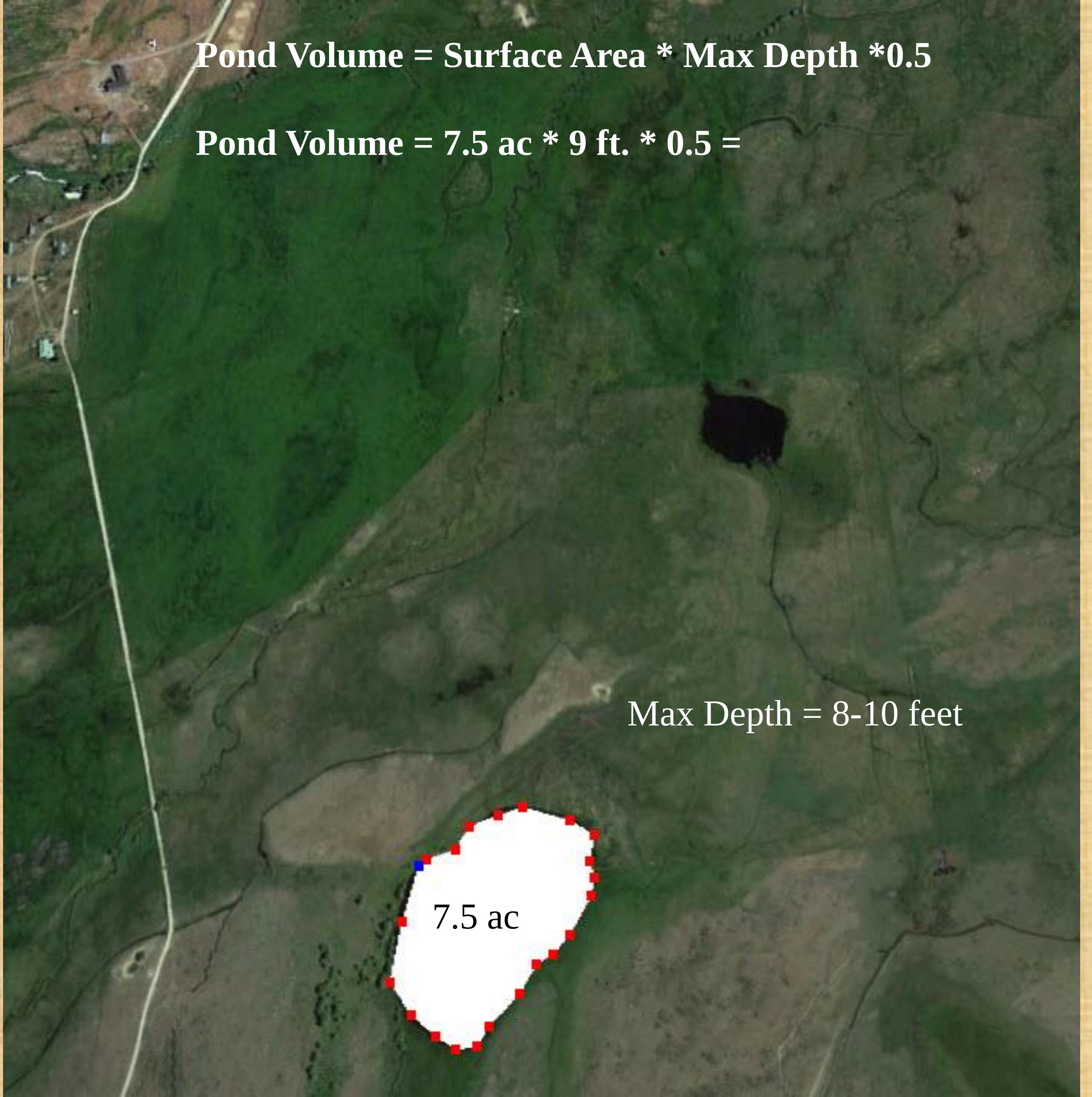
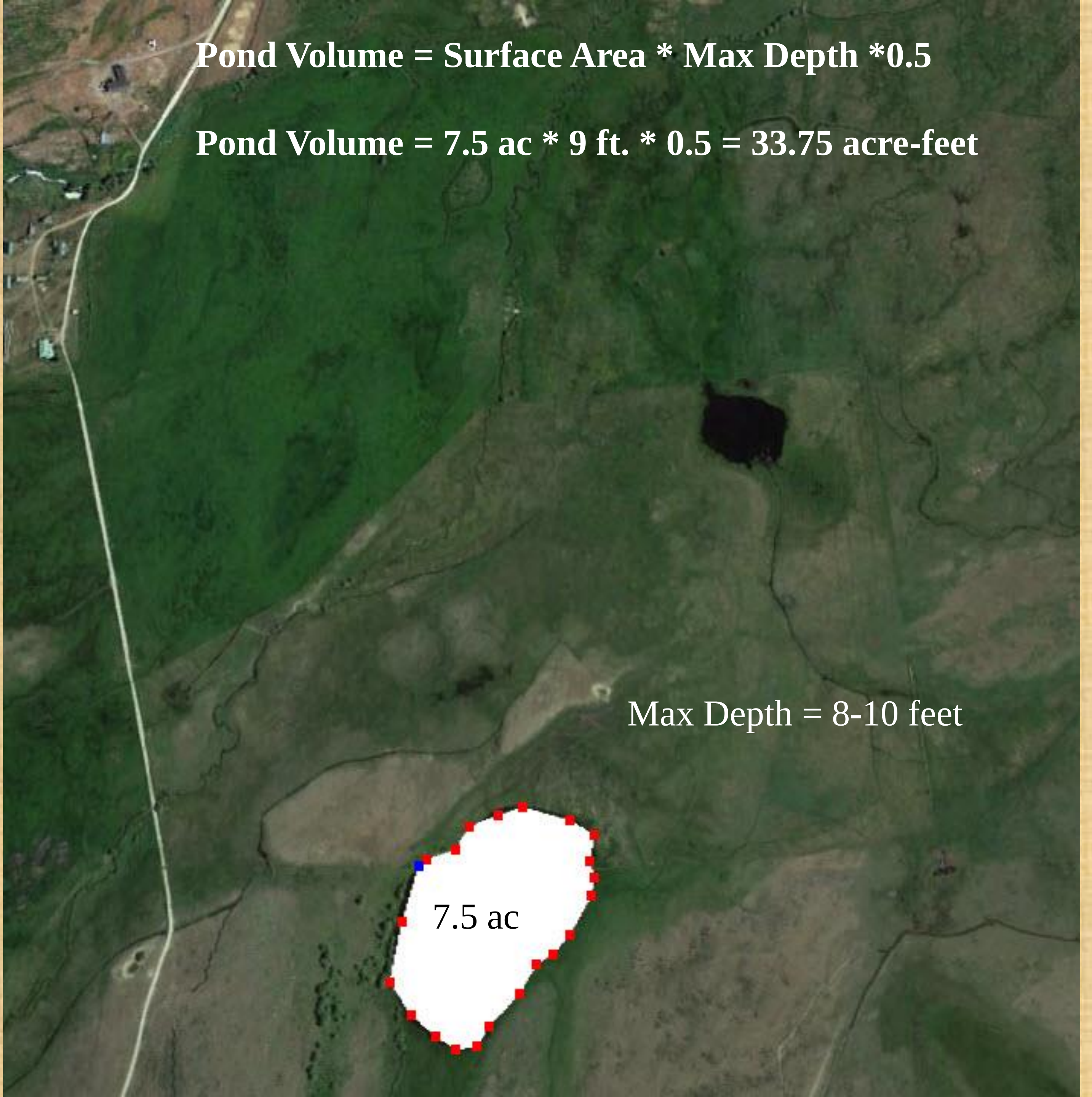
400 acre feet / 20 days = 20 ac-ft/d / 1.983 = 10.1 cfs


Pond Volume = Surface Area * Max Depth *0.5



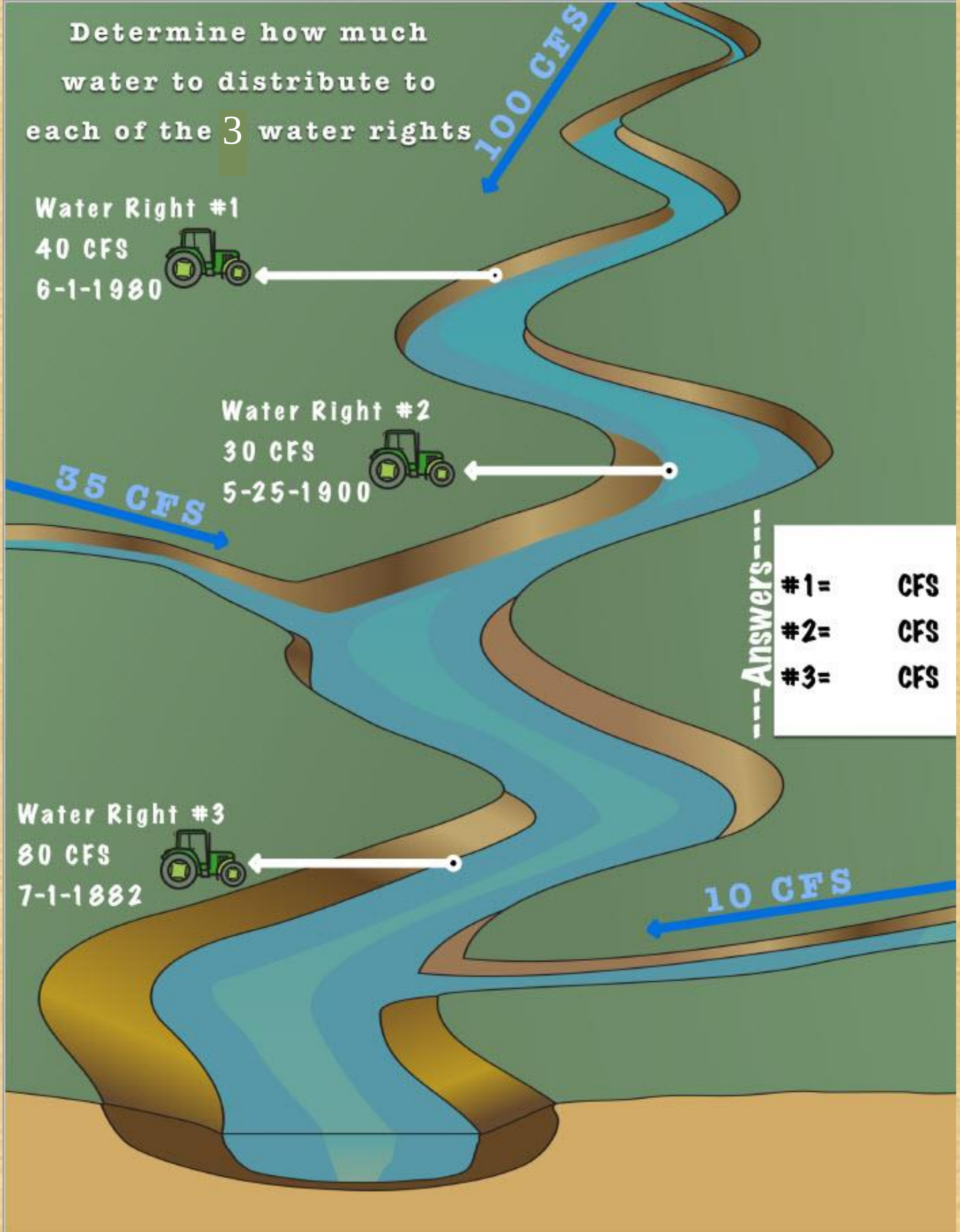
Pond Volume = Surface Area * Max Depth *0.5
Pond Volume = 7.5 ac * 9 ft. * 0.5 =
Max Depth = 8-10 feet
7.5 ac



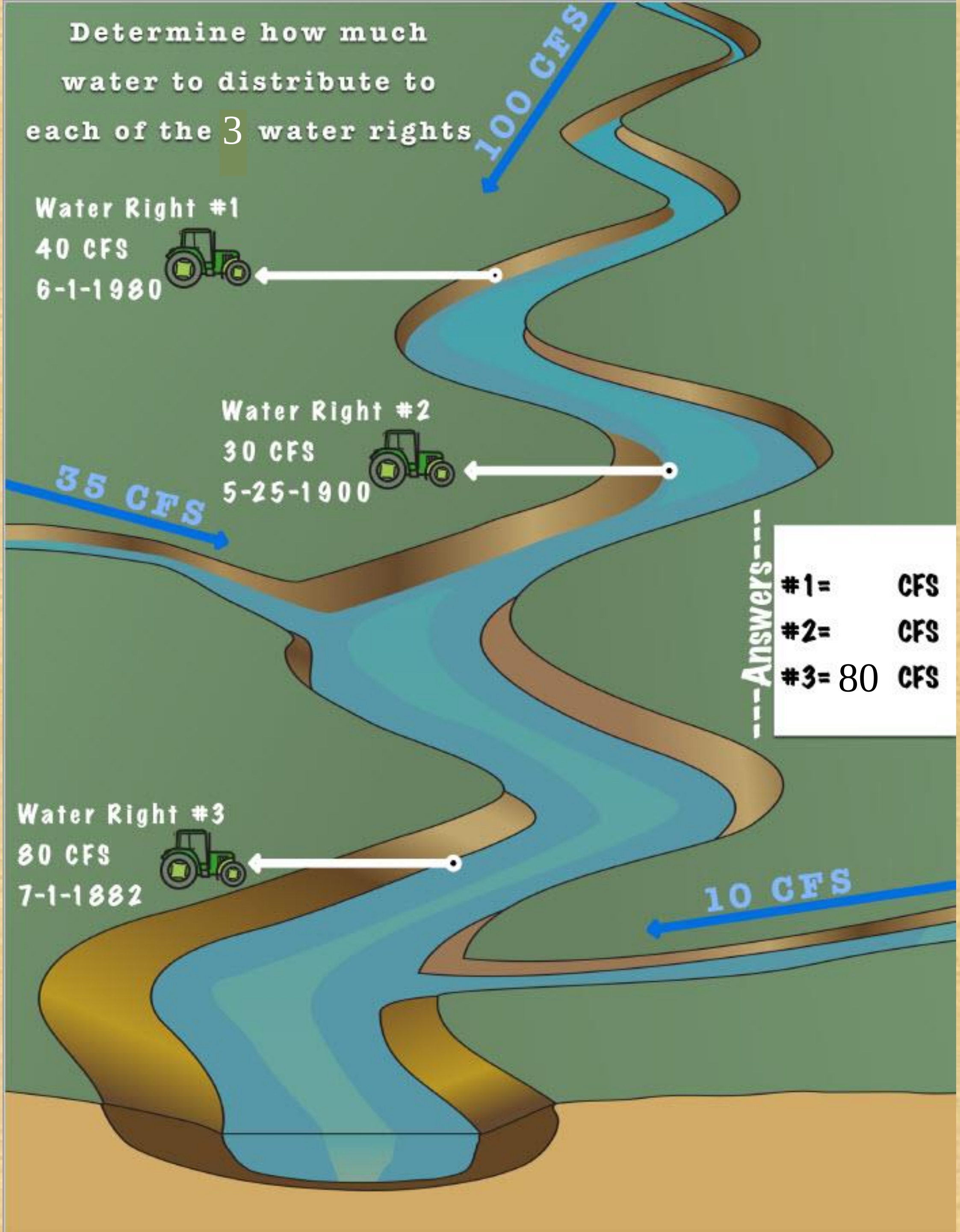
Pond Volume = Surface Area * Max Depth *0.5
Pond Volume = 7.5 ac * 9 ft. * 0.5 = 33.75 acre-feet
Max Depth = 8-10 feet
7.5 ac

Water Distribution

- Priority and Instream Flow
- Decreed vs. Stored Waters
- Understanding hydrology of system



Determine how much water to distribute to each of the 3 water rights
100 CFS
Water Right #1
40 CFS
6-1-1980
Water Right #2
30 CFS
5-25-1900
35 CFS
Answers
#1= CFS
#2= CFS
#3= CFS
Water Right #3
80 CFS
7-1-1882
10 CFS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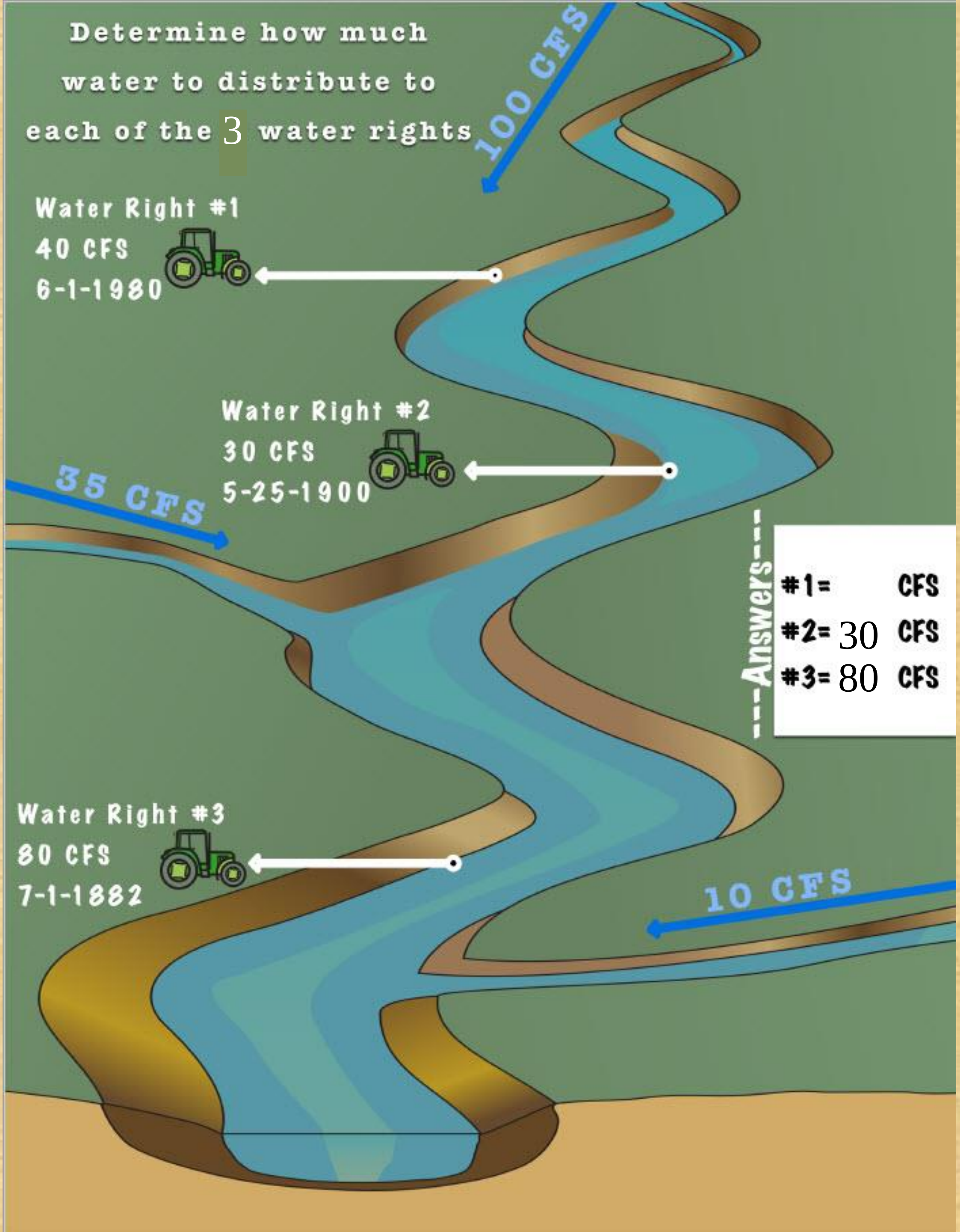
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Water Right #3
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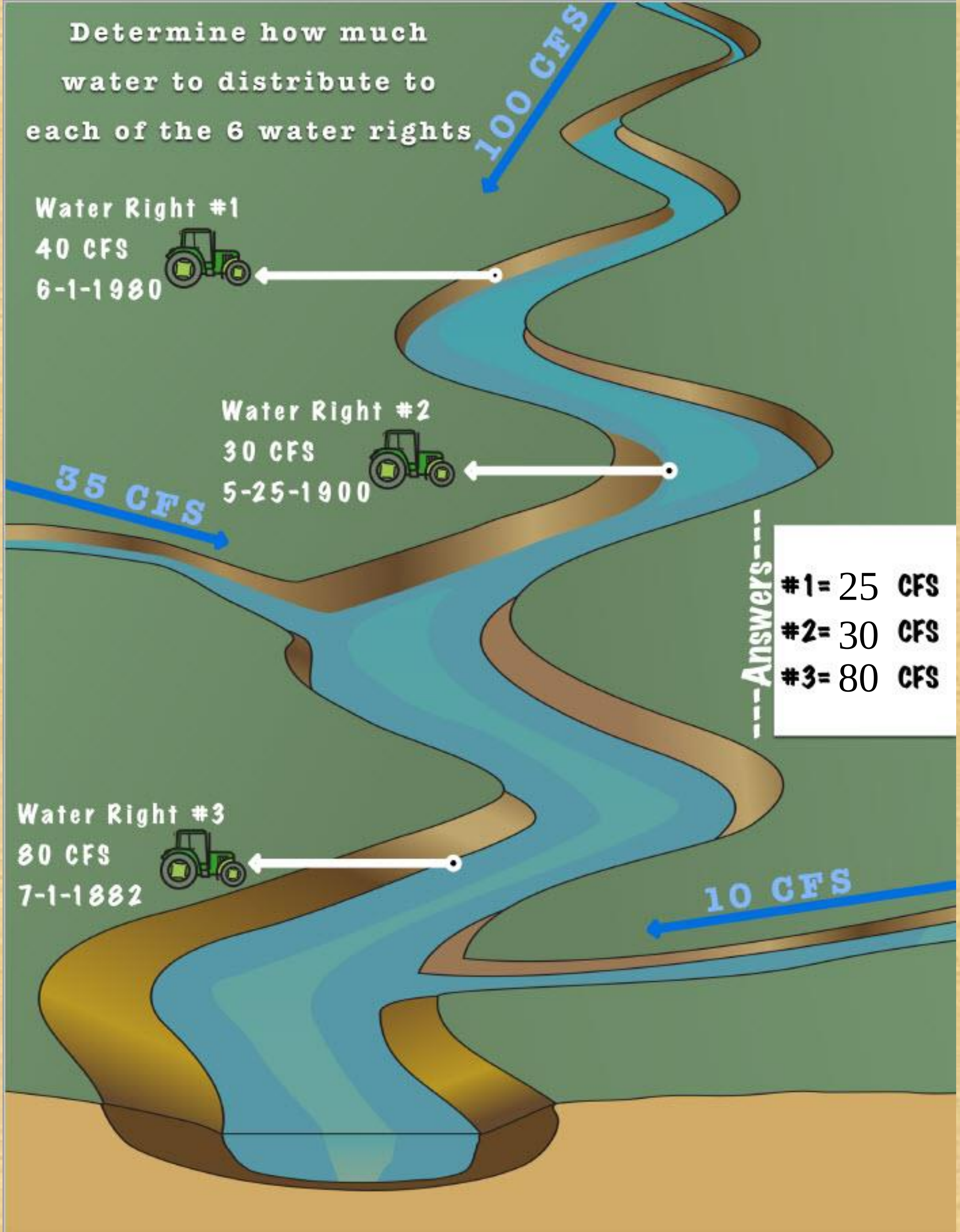
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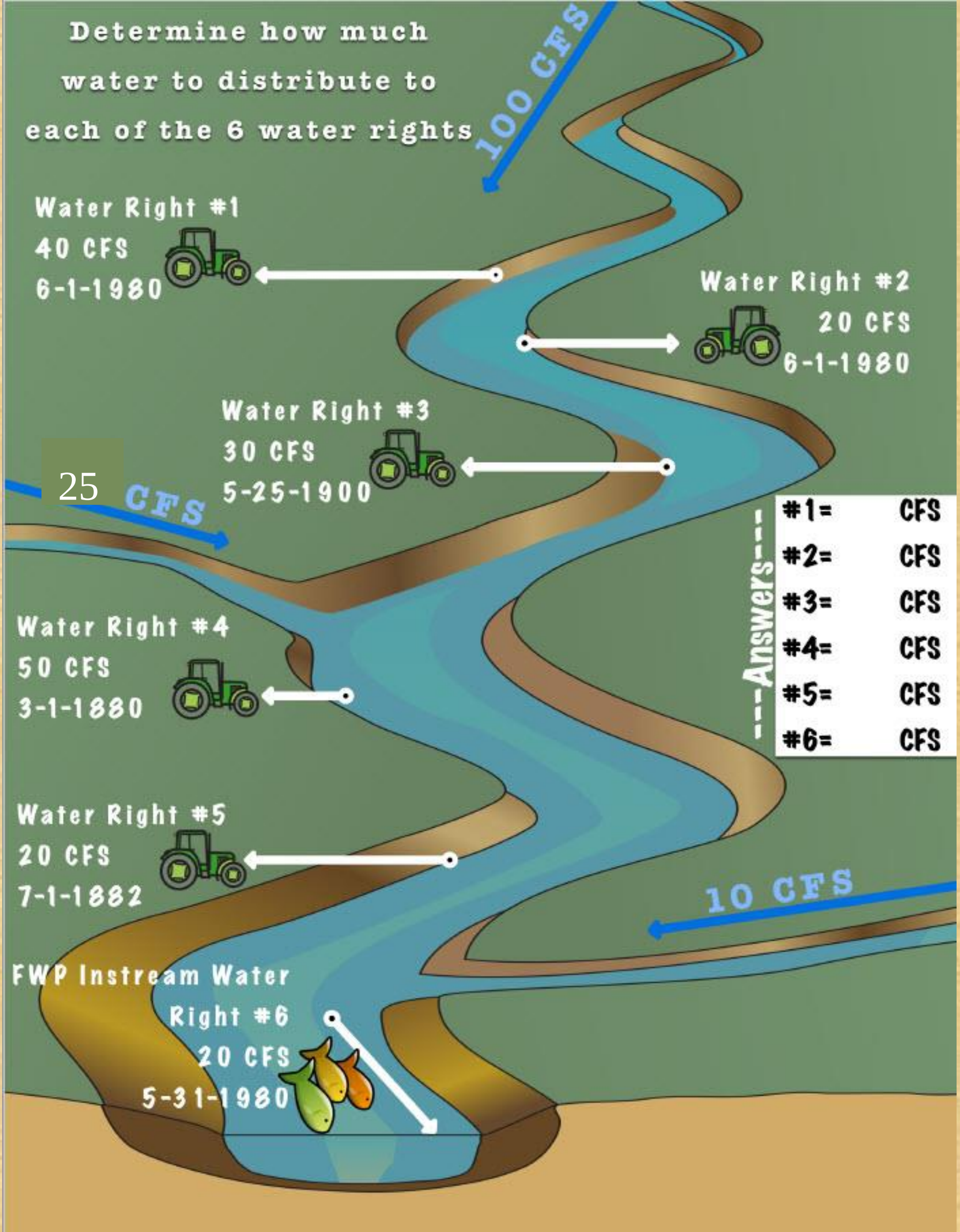
Water Right #2
30 CFS
5-25-1900
35 CFS
Answers
#1= 25 CFS
#2= 30 CFS
#3= 80 CFS
Water Right #3
80 CFS
7-1-1882
10 CFS



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25 CFS
Water Right #4
50 CFS
3-1-1880
Water Right #5
20 CFS
7-1-1882
10 CFS
FWP Instream Water Right #6
20 CFS
5-31-1980
Answers
#1= CFS
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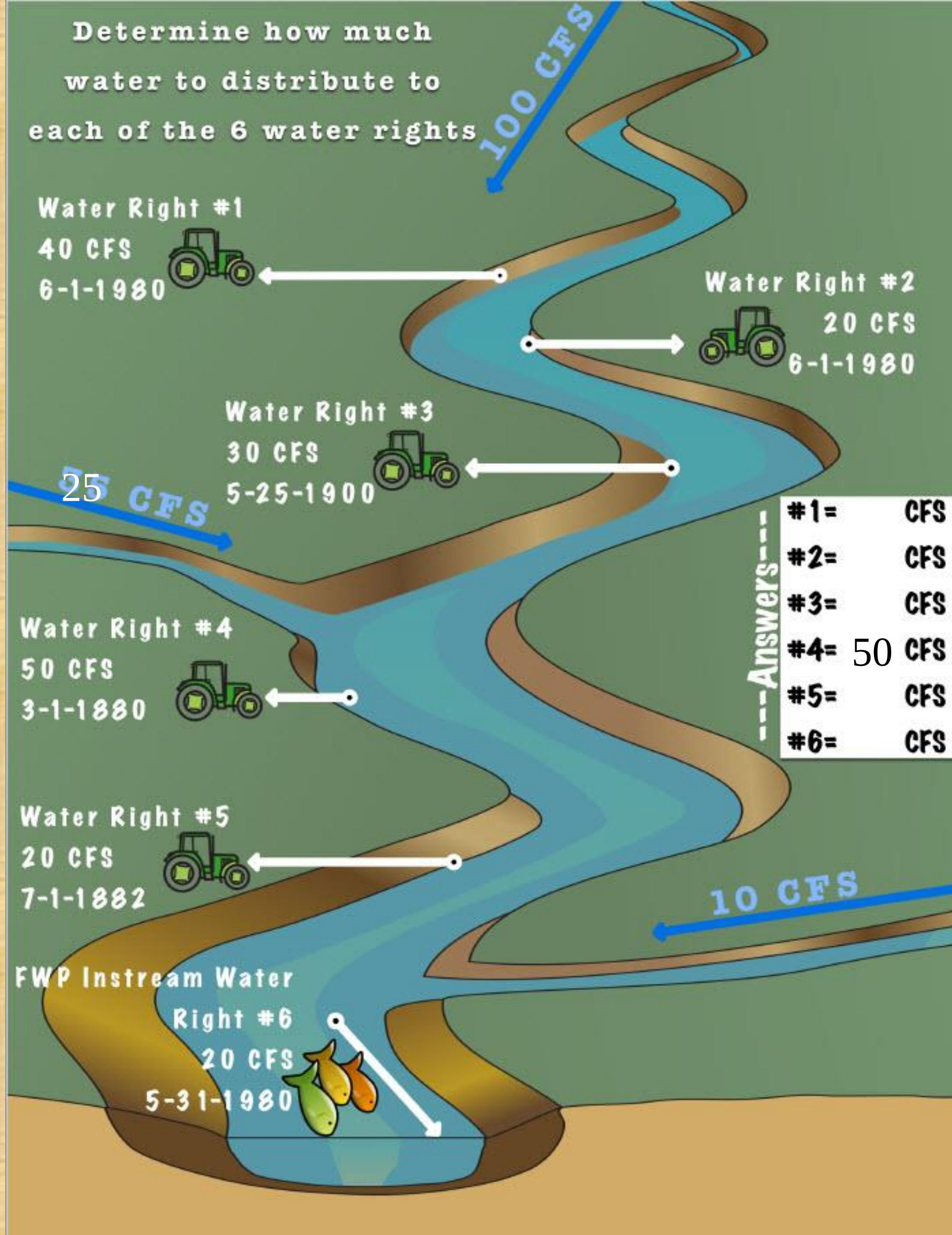
#3= CFS
#4= CFS
#5= CFS
#6= CFS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#1= CFS
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#3= CFS
#4= 50 CFS
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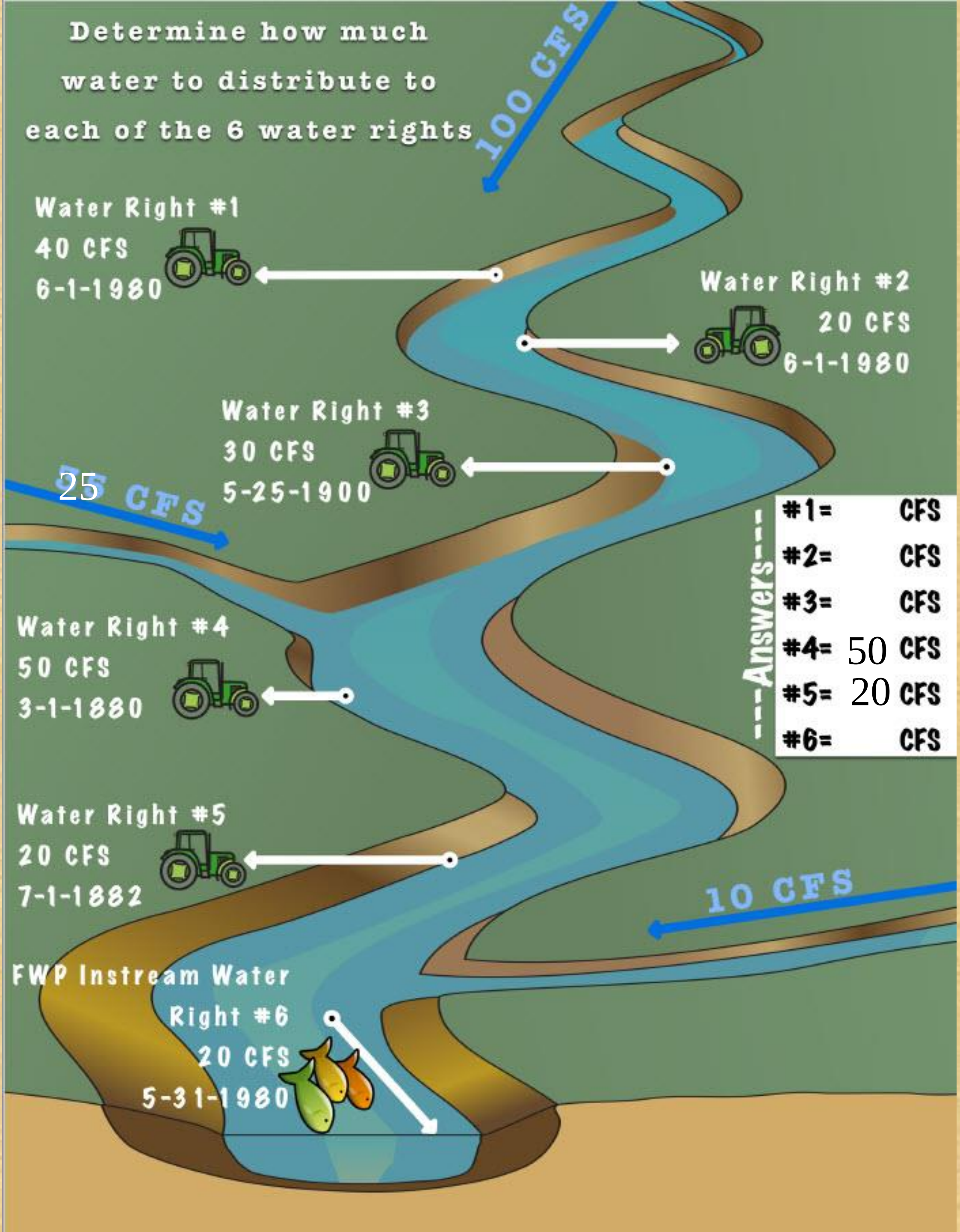
#6= CFS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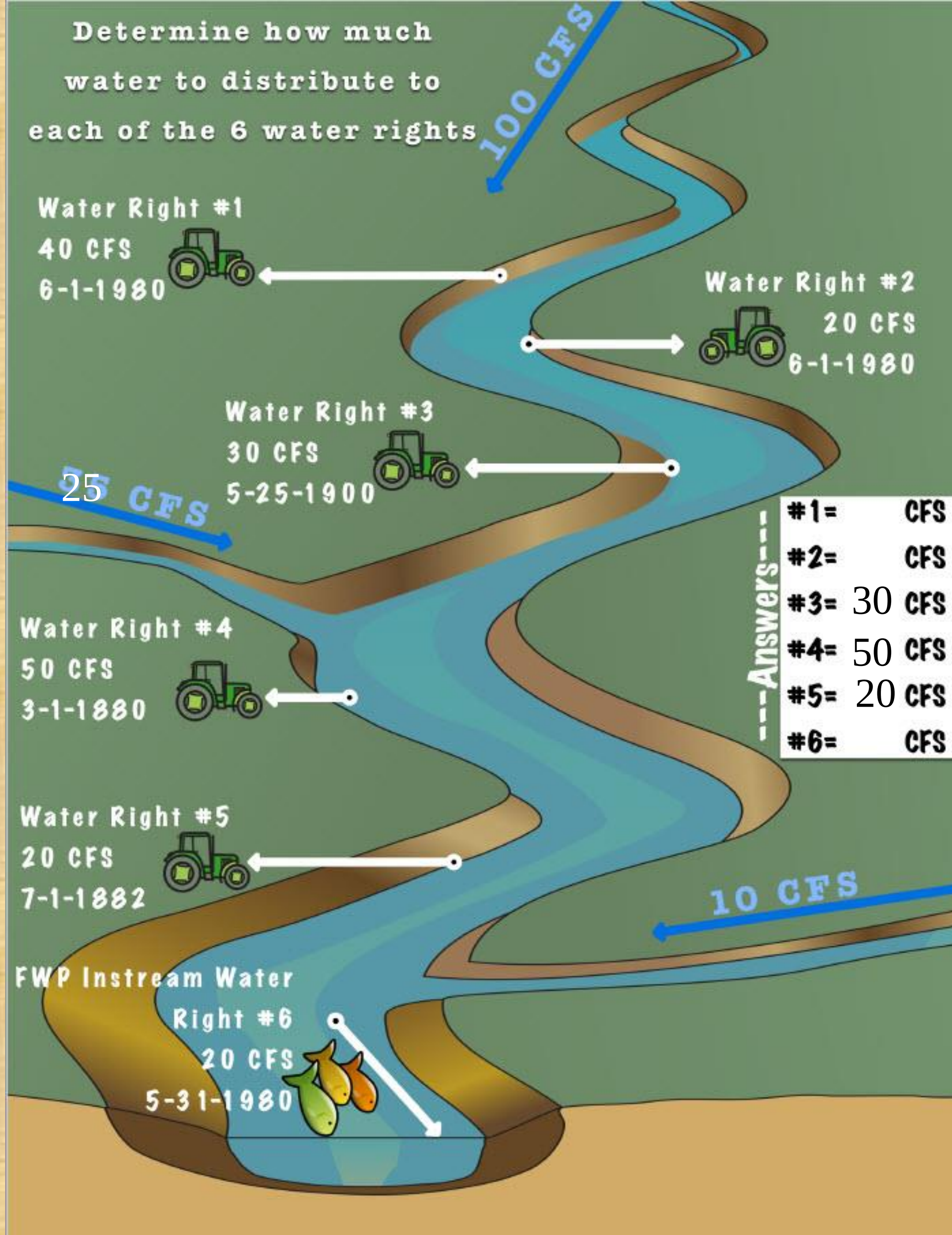
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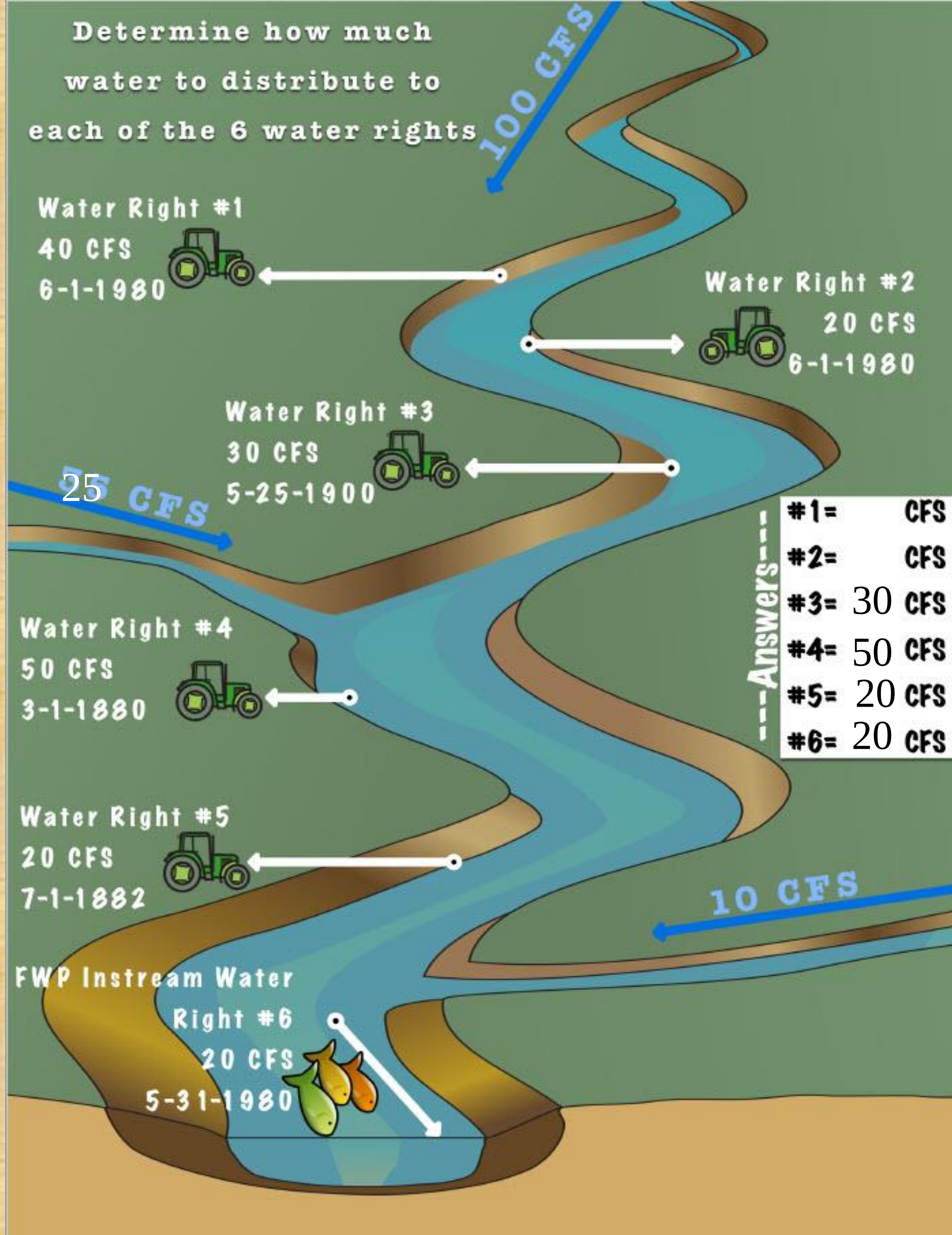
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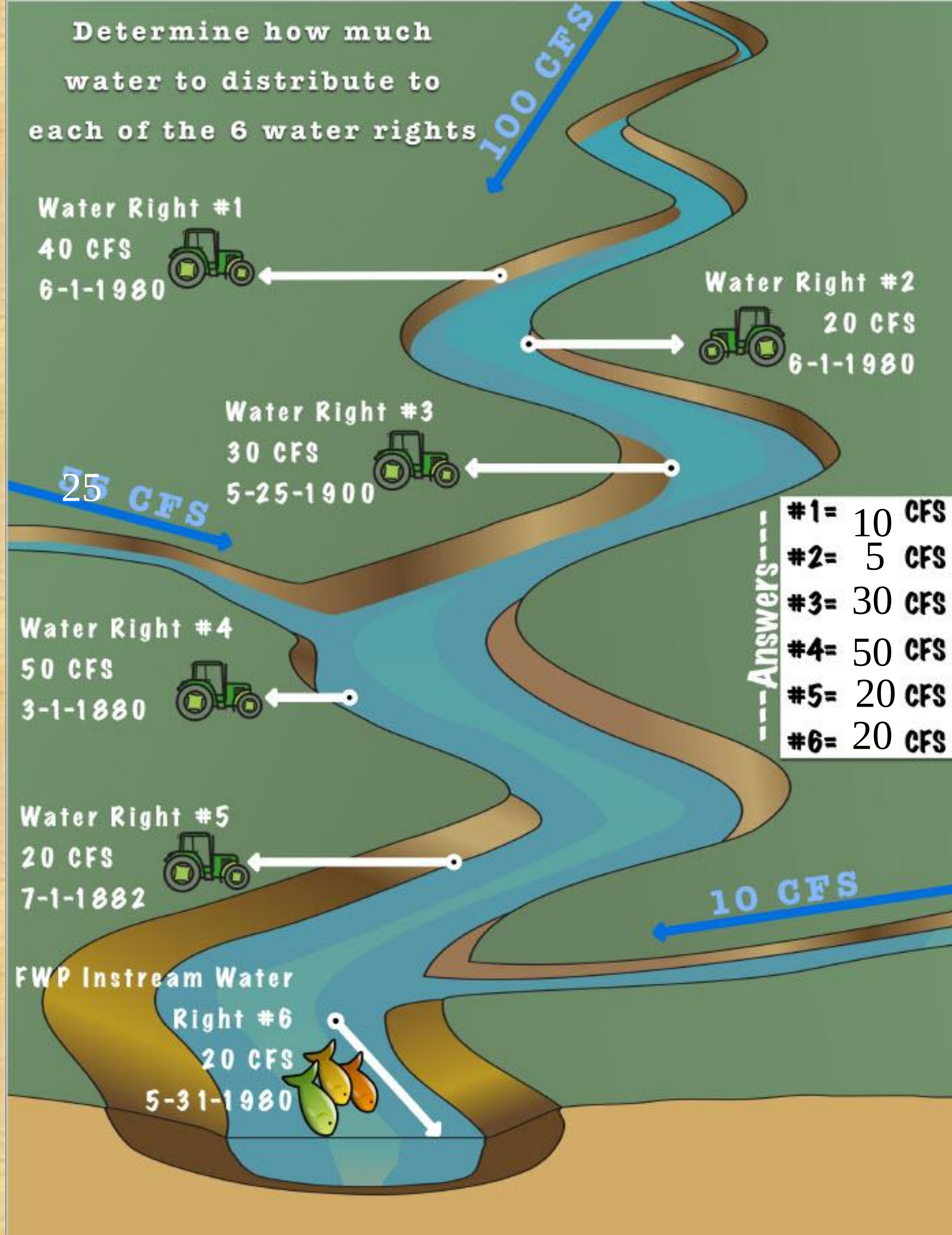
#6= 20 CFS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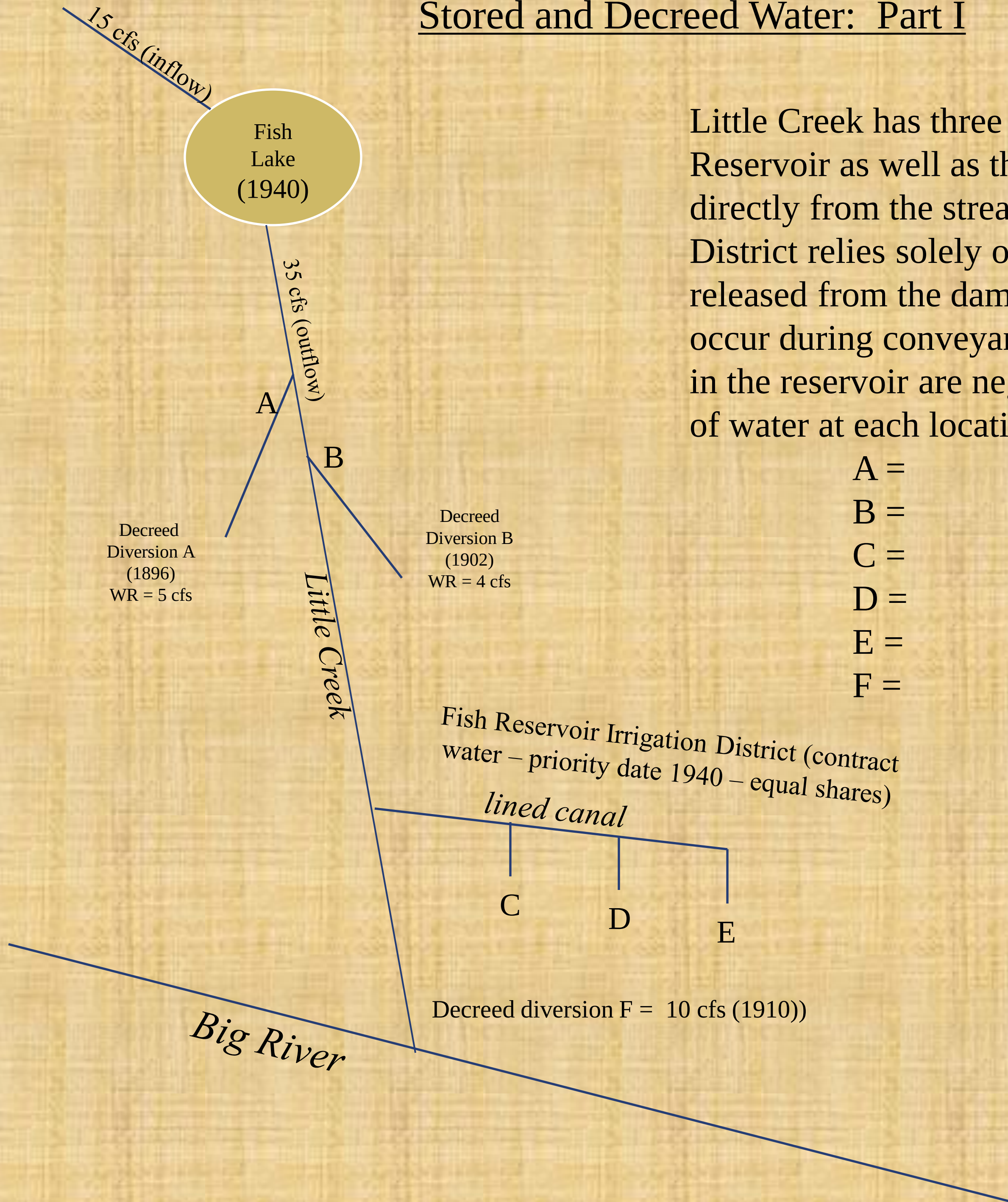
#4= 50 CFS
#5= 20 CFS
#6= 20 CFS

Reality Check -- What if you have no flow data??

Stored and Decreed Water: Part I



Little Creek has three water right contracts from Fish Reservoir as well as three decreed water rights directly from the stream. The Fish Lake Irrigation District relies solely on the 20 cfs of stored water released from the dam. No seepage losses or gains occur during conveyance. If evaporation and seepage in the reservoir are negligible, determine the amount of water at each location.

A =

B =

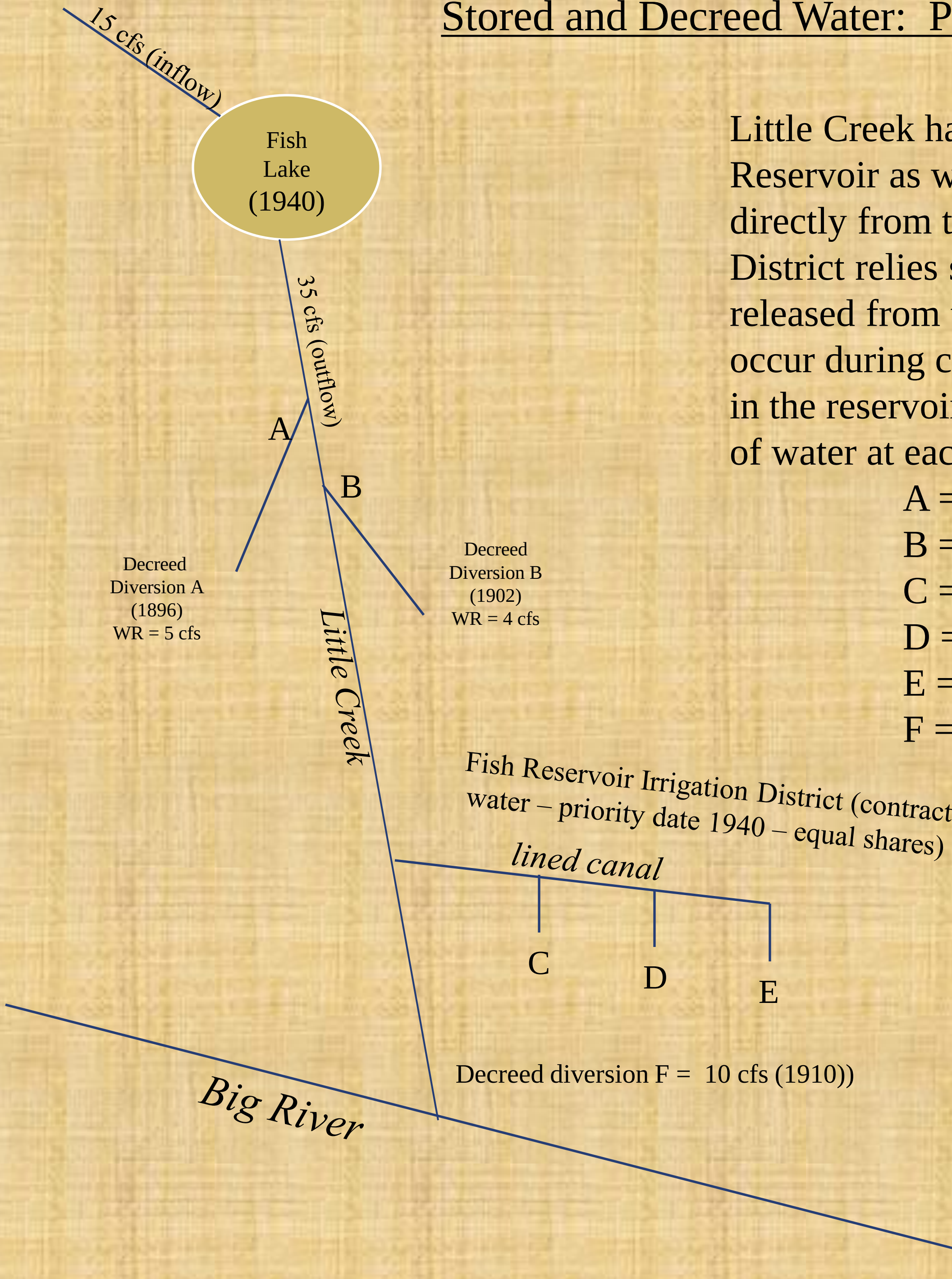
C =

D =

E =

F =

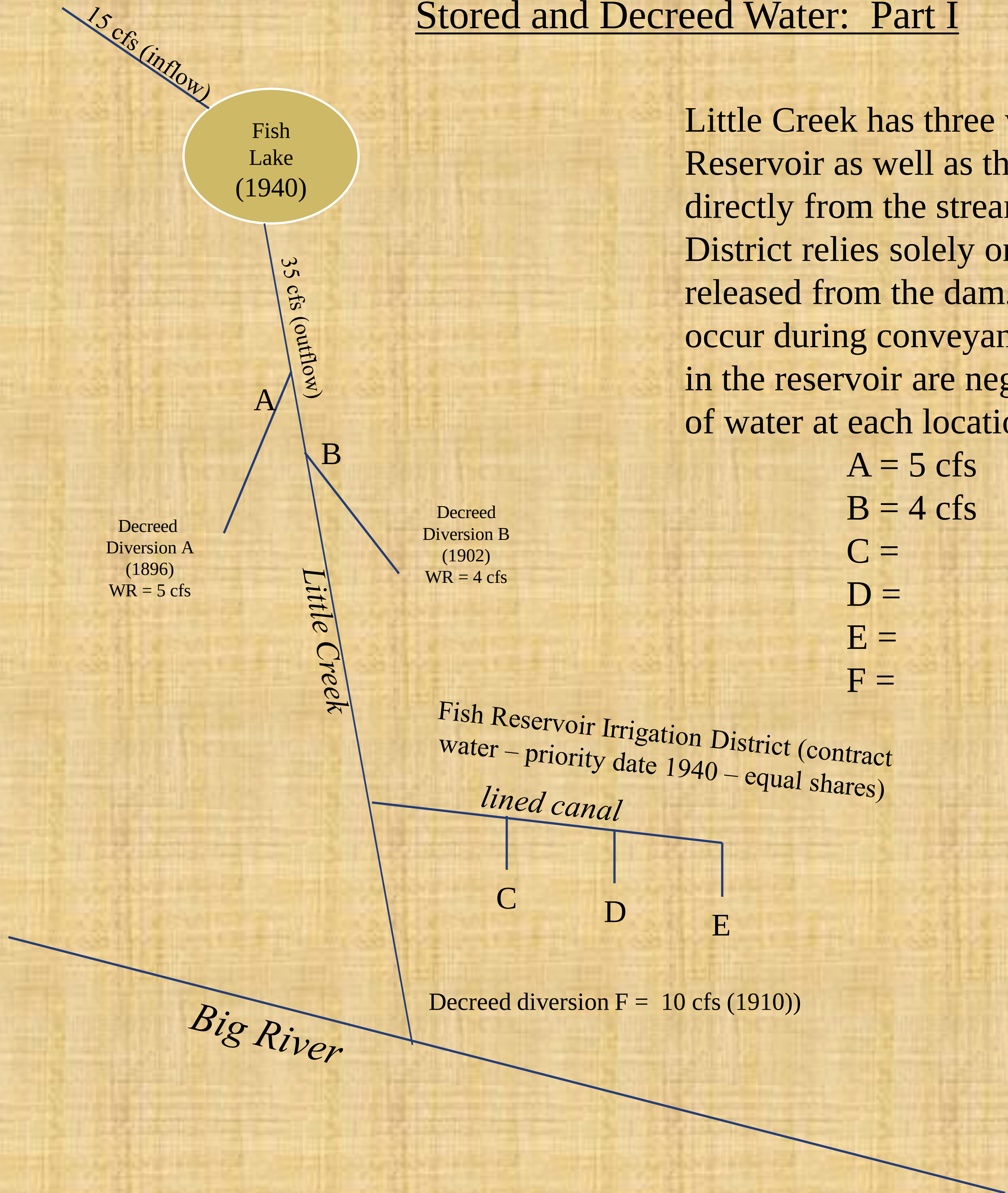
Stored and Decreed Water: Part I



Little Creek has three water right contracts from Fish Reservoir as well as three decreed water rights directly from the stream. The Fish Lake Irrigation District relies solely on the 20 cfs of stored water released from the dam. No seepage losses or gains occur during conveyance. If evaporation and seepage in the reservoir are negligible, determine the amount of water at each location.

A = 5 cfs
B =
C =
D =
E =
F =

Stored and Decreed Water: Part I



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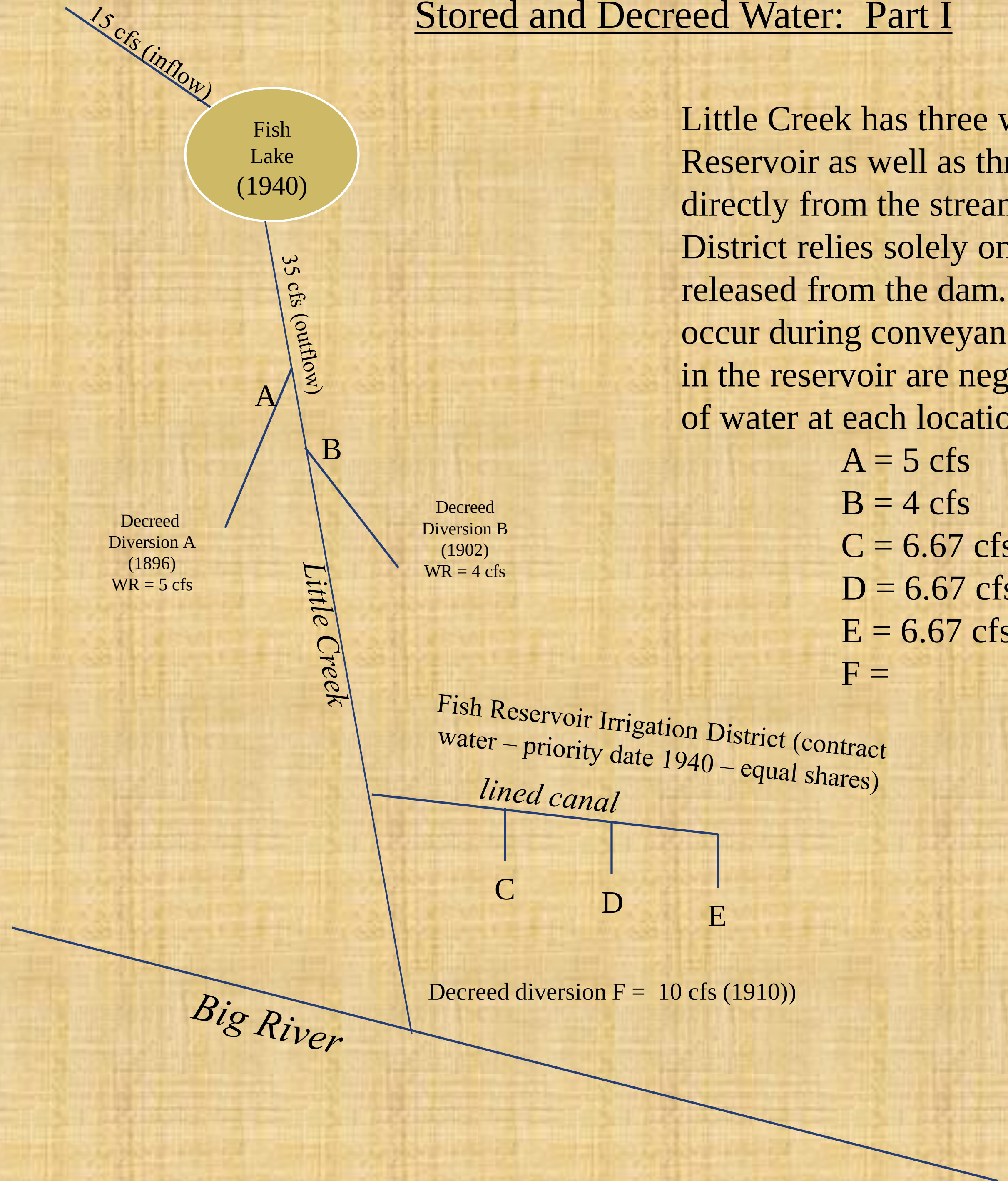
A = 5 cfs
B = 4 cfs
C =
D =
E =
F =

Stored and Decreed Water: Part I



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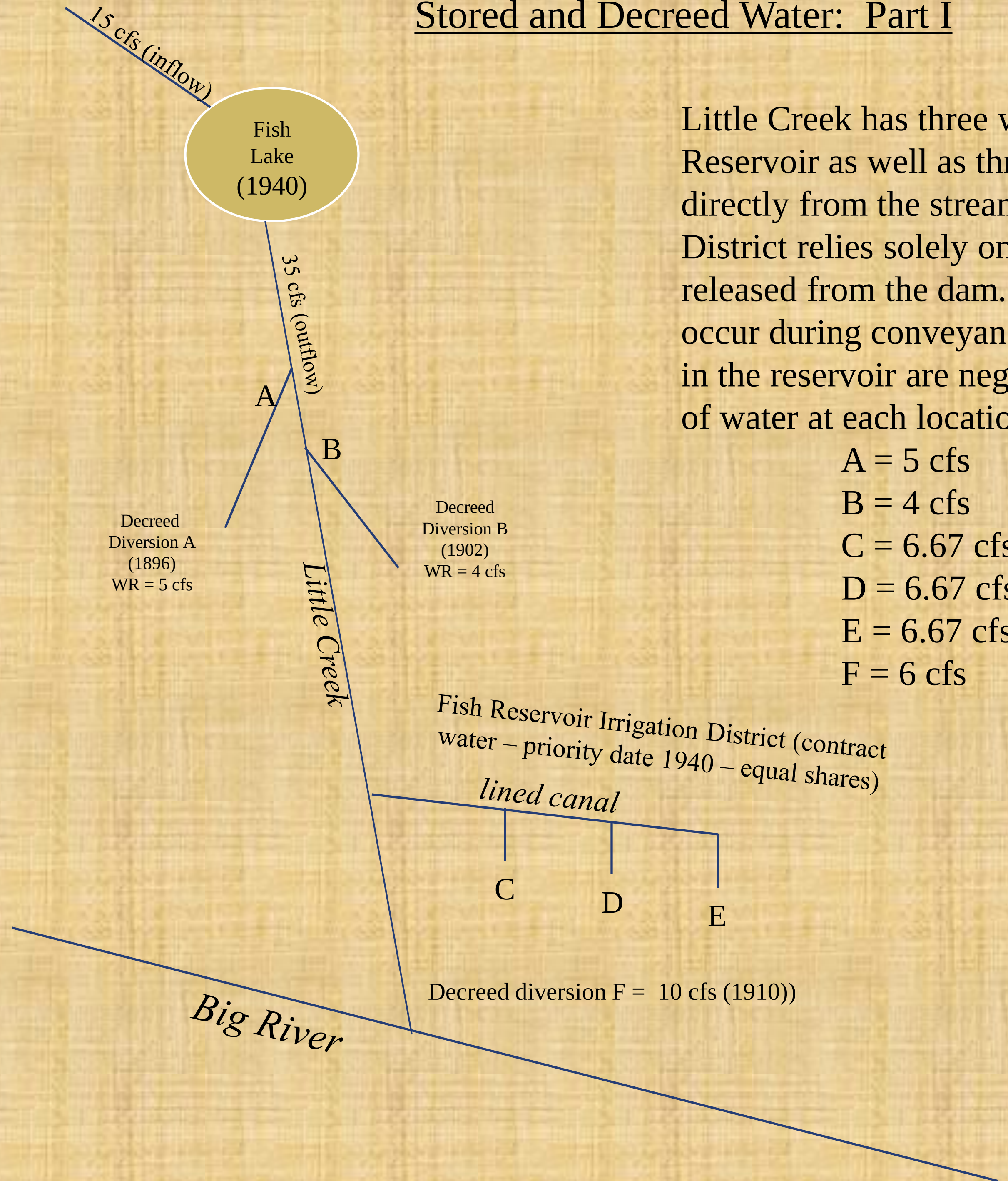
A = 5 cfs
B = 4 cfs
C = 6.67 cfs
D = 6.67 cfs
E = 6.67 cfs
F =

Stored and Decreed Water: Part I

Little Creek has three water right contracts from Fish Reservoir as well as three decreed water rights directly from the stream. The Fish Lake Irrigation District relies solely on the 20 cfs of stored water released from the dam. No seepage losses or gains occur during conveyance. If evaporation and seepage in the reservoir are negligible, determine the amount of water at each location.

A = 5 cfs
B = 4 cfs
C = 6.67 cfs
D = 6.67 cfs
E = 6.67 cfs
F = 6 cfs



Stored and Decreed Water: Part II

Little Creek has three water right contracts from Fish Reservoir as well as two decreed water rights directly from the stream. The Fish Lake Irrigation District relies solely on the 20 cfs of stored water released from the dam. **The channel loses 1 cfs/mile to seepage below the reservoir**. If evaporation and seepage in the reservoir are negligible, determine the amount of water at each location.

A =

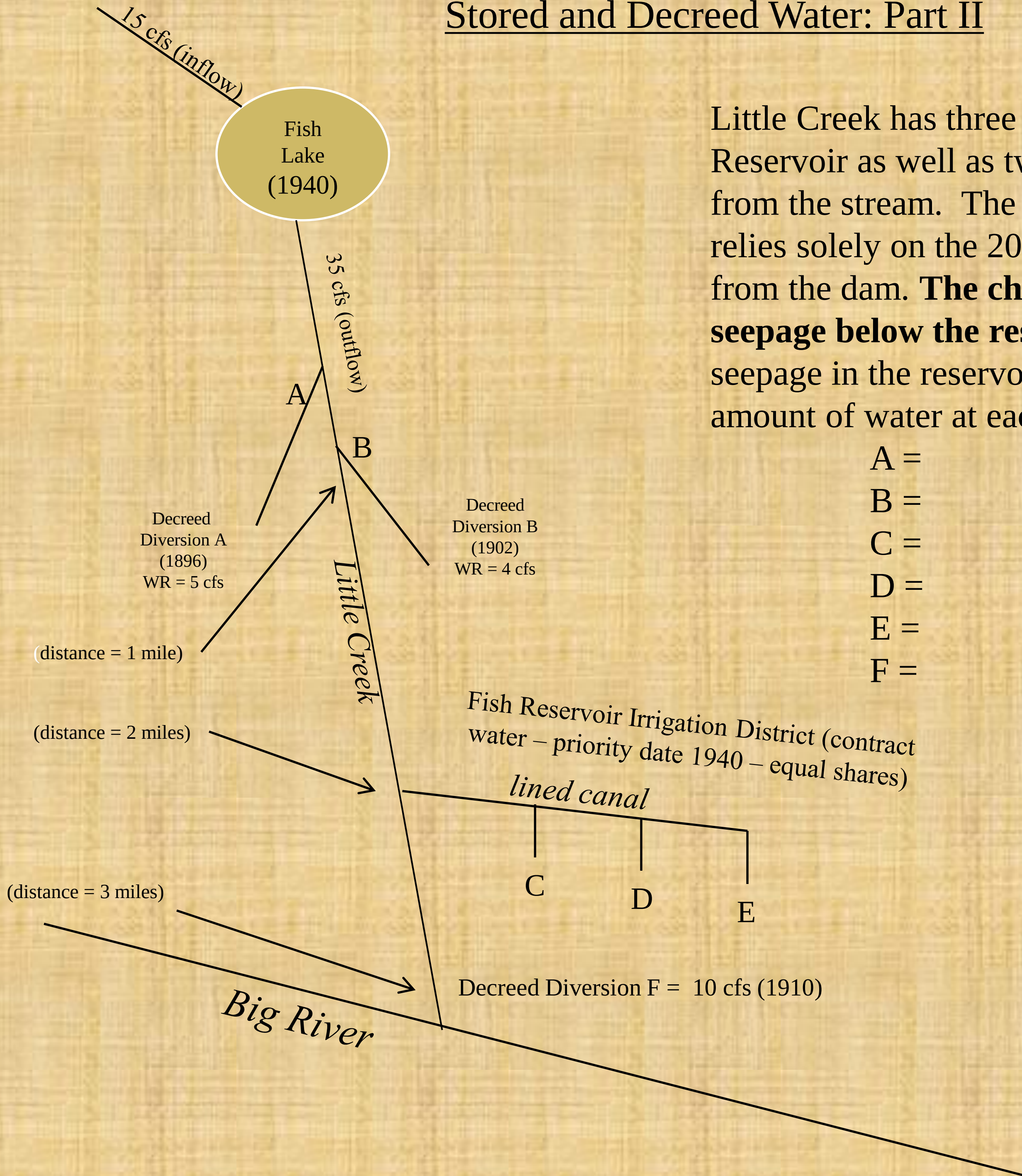
B =

C =

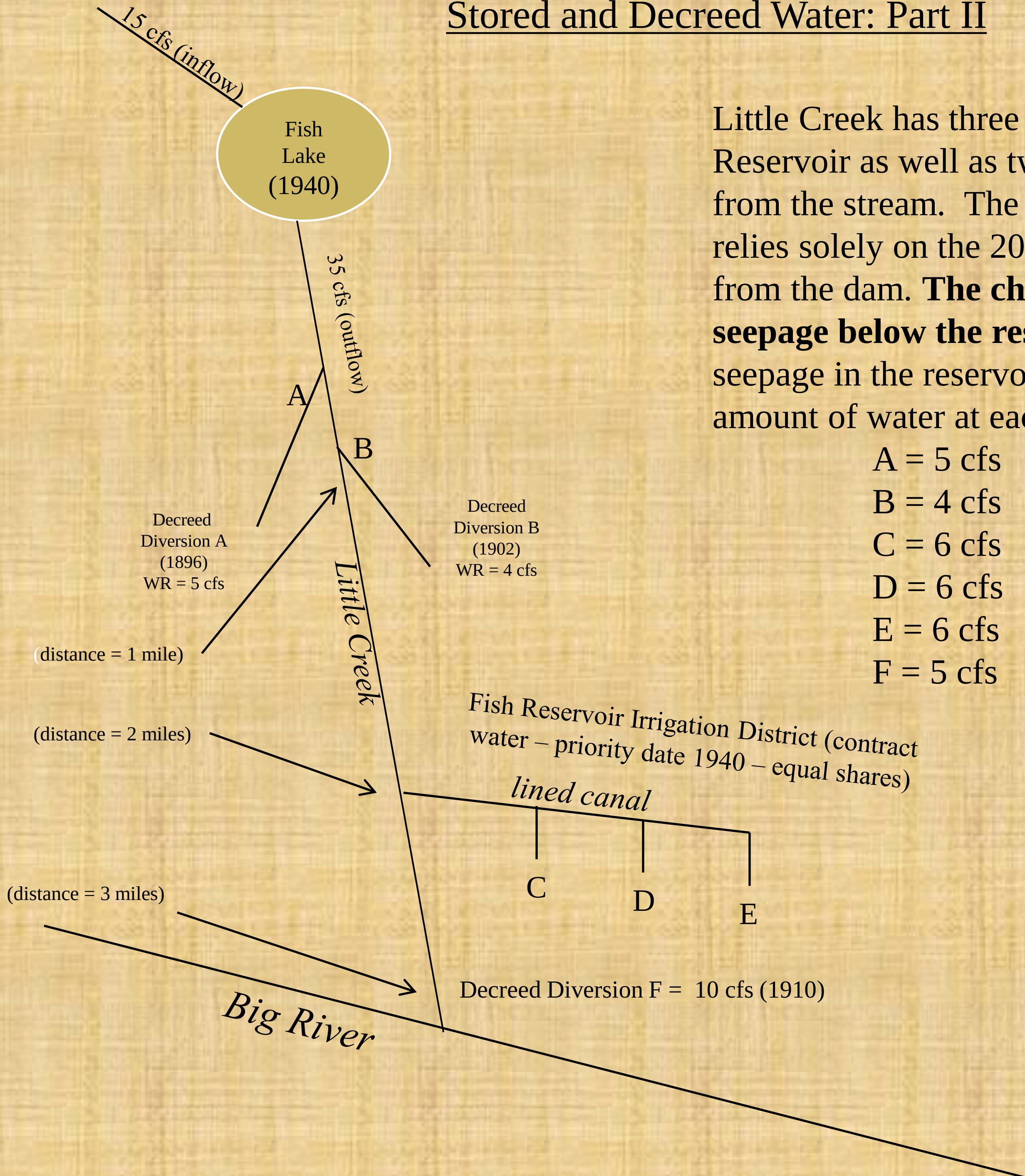
D =

E =

F =



Stored and Decreed Water: Part II



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A = 5 cfs
B = 4 cfs
C = 6 cfs
D = 6 cfs
E = 6 cfs
F = 5 cfs

Reality Check -- How do actual Water Commissioners address conveyance loss ("shrink")?

A small reservoir has 25,000 acre-feet of water in storage on July 1. For the sake of this problem, assume no seepage or evaporation occurs. Between July 1 and August 31, average reservoir inflows equal 15 cfs. Irrigators require 3200 inches, 24 hours a day, from the reservoir. Lakeside residents constantly pump 2750 gpm from the reservoir for domestic water supply and water must be released from the dam at a rate of 7.5 cfs to satisfy FWP's in-stream flow lease for west-slope cutthroat. **How many acre-feet of water are left in the reservoir on September 1?**

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September 1 storage = (July storage + Inflows) – (Outflows)

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September 1 storage = (July 1 storage + Inflows) – (Outflows)

Inflows: 15 cfs * 1.983 acre-feet/day/cfs * 62 days = **1844 acre-feet**

Outflows: Irrigators = 3200 in/40 in = 80 cfs * 1.983 af/d/cfs = 158.6 af/d * 62 days = **9836 acre-feet**

Residents = 2750 gpm/448.8 gpm/cfs = 6.13 cfs*1.983 af/d/cfs = 12.2 af/d * 62 days = **753 acre-feet**

West-Slope Cutthroat = 7.5 cfs * 1.983 af/d/cfs * 62 d = **922 acre-feet**

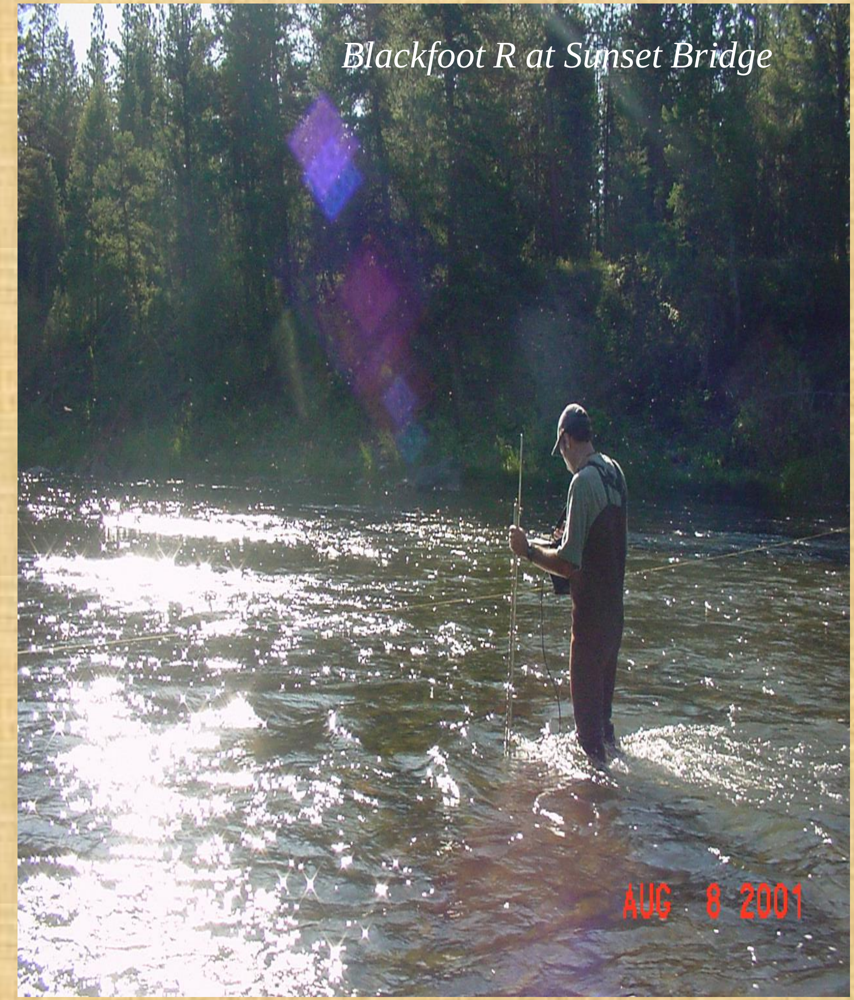
September 1 storage = (July storage + Inflows) – (Outflows)

(25,000 af + 1844 af) – (9836 af + 753 af + 922 af)

= 15,333 acre-feet

Flow Measurement Basics

Open Channel Flow



Flow Measurement Basics

Closed Conduit Flow

Water Measurement

- headgates
- flow measurement basics
- rated devices
- flumes and weirs
- automated devices
- manual measurements

- sample problems

MCA 85-5-302

….All persons using water from any stream or ditch whereon a water commissioner is appointed are required to have <u>*suitable*</u> *headgates at the point where the ditch taps a stream and shall also, at some* <u>*suitable*</u> *place on the ditch and as near the headgate as practicable, place and maintain a* <u>*proper*</u> *measuring box, weir, or other appliance for the measurement of the waters flowing in the ditch.*

What is a suitable headgate?

<u>**“Suitable” Headgate**</u>

per ARM 36.13.101(9)

- ➢ Can be closed completely
- ➢ Adequately vary amount diverted

And, not in ARM

- ➢ Can be operated by one person


Suitable headgate?


Suitable Headgate??


MAR 30 2004

Rock Headgate – not properly functioning

functional

not so functional

Diversion Dams

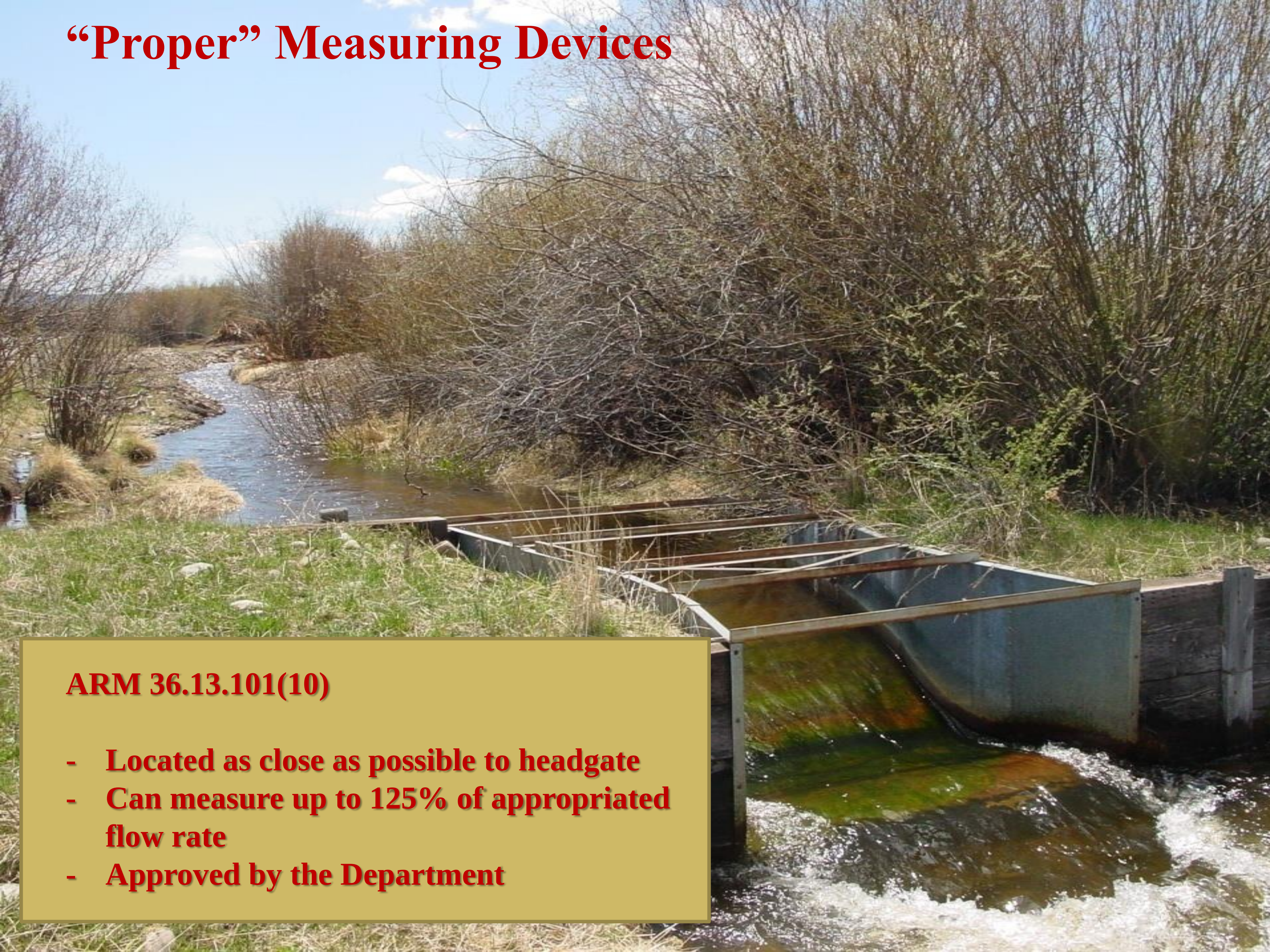
“Suitable” Location of Measuring Device

- depends on conveyance, logistics, ability to adjust flows, proximity to turbulent flow, etc.


pin and plank diversion dam
Waterman
screwgate
Parshall flume
measuring device
fish ladder


measuring device
MAR 30 2004

“Proper” Measuring Devices



ARM 36.13.101(10)

- Located as close as possible to headgate
- Can measure up to 125% of appropriated flow rate
- Approved by the Department

Water Measurement Devices

- Rated and standard devices - staff gages, flumes, weirs, orifices, weir sticks

- Automated devices - gaging station, propeller meters, in-line meters, ultra-sonic meters, totalizers

- Manual measurement - current meters, estimation techniques (float-area method)

Open Channel Rated Devices

Staff Gages
Flumes
Weirs
Weir Sticks

definitions

Stage - height of water surface above an established datum
ex. staff gage reading

Discharge - volume of flow passing a point usually expressed
(flow rate) in cubic feet per second (cfs) or inches.

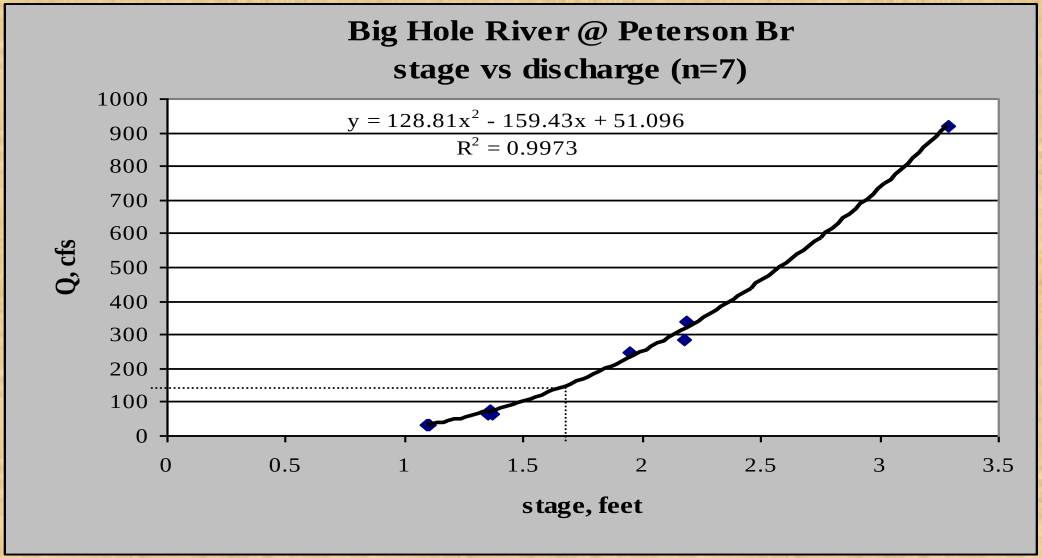
Rating – relationship between the stage of the stream/canal and the discharge.

Staff Gages

Stage = 1.16 feet

Stage = 0.67 feet

wire weight gage



stage	discharge	stage	discharge	stage	discharge
1.5	102	1.56	116	1.62	131
1.51	104	1.57	118	1.63	133
1.52	106	1.58	121	1.64	136
1.53	109	1.59	123	1.65	139
1.54	111	1.6	126	1.66	141
1.55	113	1.61	128	1.67	144

staff gage rating

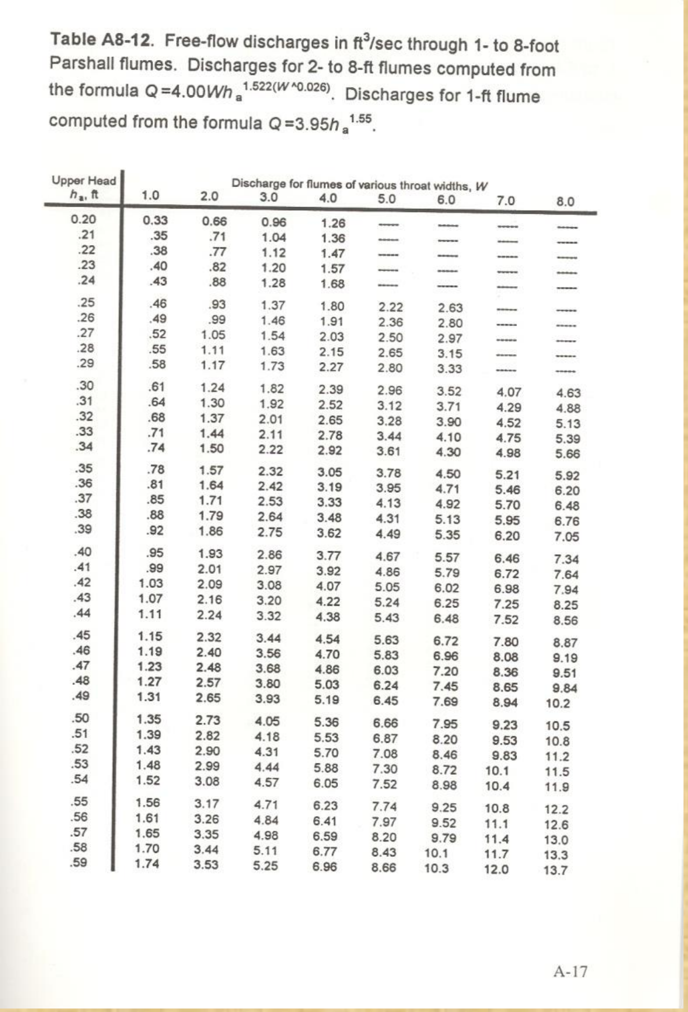


Table A8-12. Free-flow discharges in ft³/sec through 1- to 8-foot Parshall flumes. Discharges for 2- to 8-ft flumes computed from the formula $Q = 4.00 W h_a^{1.522(W^{0.026})}$. Discharges for 1-ft flume computed from the formula $Q = 3.95 h_a^{1.55}$.

Upper Head h_a, ft	Discharge for flumes of various throat widths, W							
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
0.20	0.33	0.66	0.96	1.26	-----	-----	-----	-----
.21	.35	.71	1.04	1.36	-----	-----	-----	-----
.22	.38	.77	1.12	1.47	-----	-----	-----	-----
.23	.40	.82	1.20	1.57	-----	-----	-----	-----
.24	.43	.88	1.28	1.68	-----	-----	-----	-----
.25	.46	.93	1.37	1.80	2.22	2.63	-----	-----
.26	.49	.99	1.46	1.91	2.36	2.80	-----	-----
.27	.52	1.05	1.54	2.03	2.50	2.97	-----	-----
.28	.55	1.11	1.63	2.15	2.65	3.15	-----	-----
.29	.58	1.17	1.73	2.27	2.80	3.33	-----	-----
.30	.61	1.24	1.82	2.39	2.96	3.52	4.07	4.63
.31	.64	1.30	1.92	2.52	3.12	3.71	4.29	4.88
.32	.68	1.37	2.01	2.65	3.28	3.90	4.52	5.13
.33	.71	1.44	2.11	2.78	3.44	4.10	4.75	5.39
.34	.74	1.50	2.22	2.92	3.61	4.30	4.98	5.66
.35	.78	1.57	2.32	3.05	3.78	4.50	5.21	5.92
.36	.81	1.64	2.42	3.19	3.95	4.71	5.46	6.20
.37	.85	1.71	2.53	3.33	4.13	4.92	5.70	6.48
.38	.88	1.79	2.64	3.48	4.31	5.13	5.95	6.76
.39	.92	1.86	2.75	3.62	4.49	5.35	6.20	7.05
.40	.95	1.93	2.86	3.77	4.67	5.57	6.46	7.34
.41	.99	2.01	2.97	3.92	4.86	5.79	6.72	7.64
.42	1.03	2.09	3.08	4.07	5.05	6.02	6.98	7.94
.43	1.07	2.16	3.20	4.22	5.24	6.25	7.25	8.25
.44	1.11	2.24	3.32	4.38	5.43	6.48	7.52	8.56
.45	1.15	2.32	3.44	4.54	5.63	6.72	7.80	8.87
.46	1.19	2.40	3.56	4.70	5.83	6.96	8.08	9.19
.47	1.23	2.48	3.68	4.86	6.03	7.20	8.36	9.51
.48	1.27	2.57	3.80	5.03	6.24	7.45	8.65	9.84
.49	1.31	2.65	3.93	5.19	6.45	7.69	8.94	10.2
.50	1.35	2.73	4.05	5.36	6.66	7.95	9.23	10.5
.51	1.39	2.82	4.18	5.53	6.87	8.20	9.53	10.8
.52	1.43	2.90	4.31	5.70	7.08	8.46	9.83	11.2
.53	1.48	2.99	4.44	5.88	7.30	8.72	10.1	11.5
.54	1.52	3.08	4.57	6.05	7.52	8.98	10.4	11.9
.55	1.56	3.17	4.71	6.23	7.74	9.25	10.8	12.2
.56	1.61	3.26	4.84	6.41	7.97	9.52	11.1	12.6
.57	1.65	3.35	4.98	6.59	8.20	9.79	11.4	13.0
.58	1.70	3.44	5.11	6.77	8.43	10.1	11.7	13.3
.59	1.74	3.53	5.25	6.96	8.66	10.3	12.0	13.7

A-17

Parshall flume

Photo: Ethan Mace

Flumes and Weirs

Flume – shaped, open-channel flow sections that force flow to accelerate.

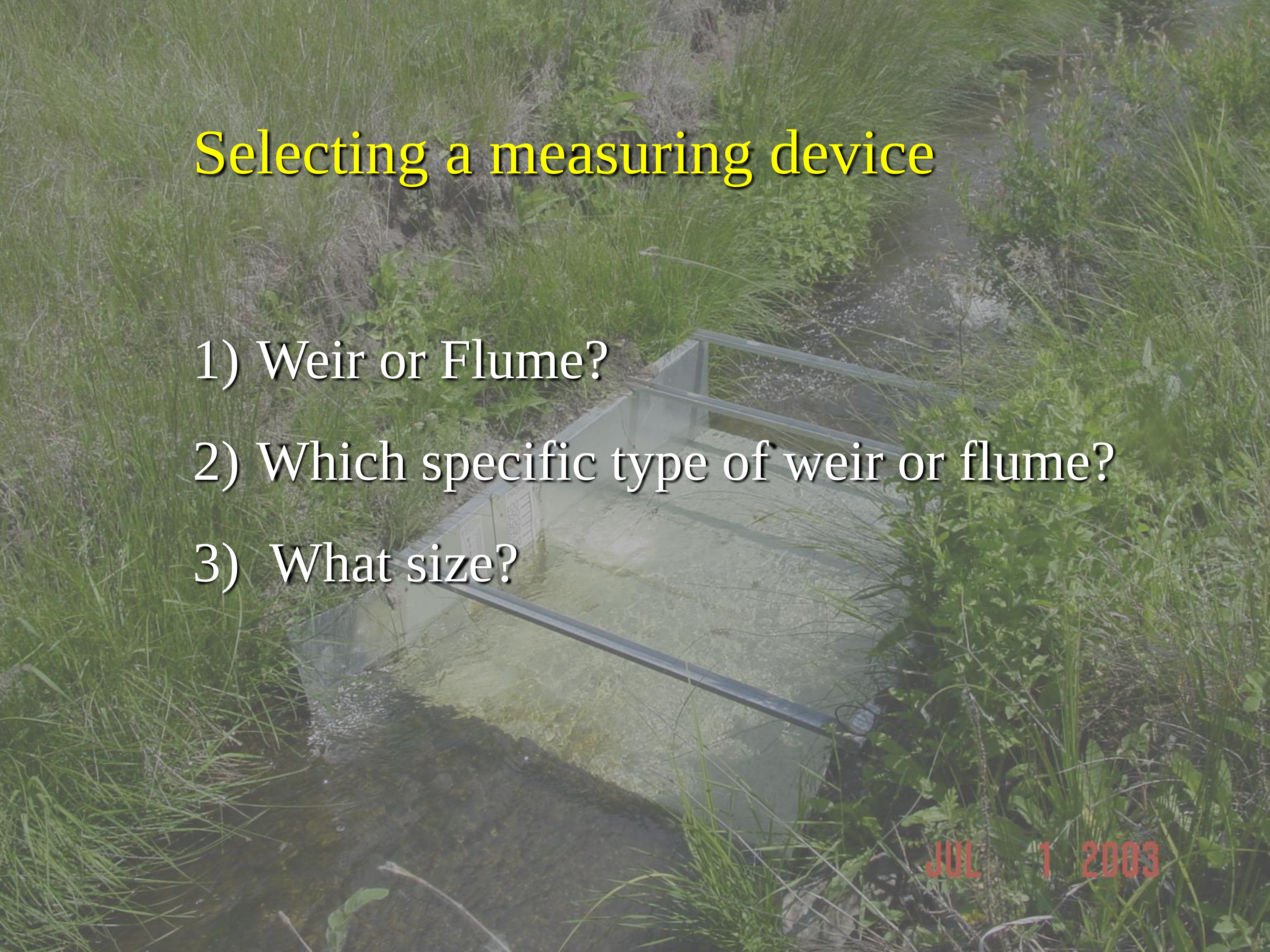
Weir – an overflow structure built perpendicular to an open channel axis to measure the rate of flow.
Slope > 0.5%

Selecting a measuring device

1) Weir or Flume?

2) Which specific type of weir or flume?

3) What size?



Flumes

- Parshall
- Montana
- Cutthroat
- Ramp

Parshall Flume

- low head loss requirement
- facilitates sand and silt
- tranquil flow (sub-critical)
  can be > 1 ft/s for approach
- wide range of sizes and flows
- can be measured under some
  submerged conditions
- difficult to build
- installation accuracy critical
- minimum head of 0.2 feet
- expensive (2.5’ throat =
  $1500 to $2500)

Specifications:

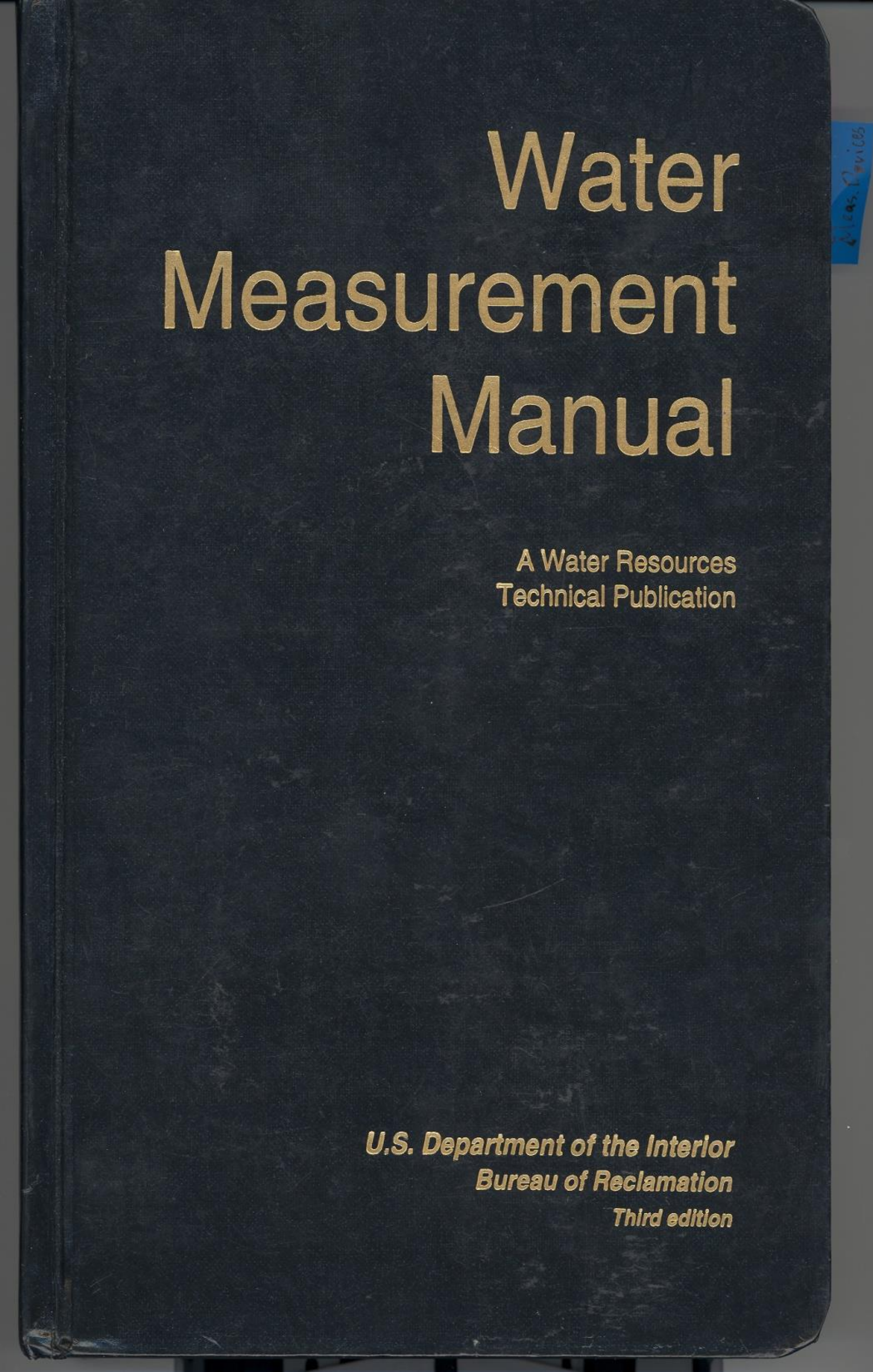
- straight section of ditch
- clear of obstructions that may disrupt even flow of approach
- floor of converging section must be level lengthwise and cross wise
- set flume floor above elevation of ditch to avoid submergence
- staff gage set at floor of converging section (crest)
- staff gage set 2/3 from crest


checking level


2/3
1/3

Throat width = 4 feet Q = ?

Stage = 0.49 feet



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.32	.68	1.37	2.01	2.65	3.28	3.90	4.52	5.13
.33	.71	1.44	2.11	2.78	3.44	4.10	4.75	5.39
.34	.74	1.50	2.22	2.92	3.61	4.30	4.98	5.66
.35	.78	1.57	2.32	3.05	3.78	4.50	5.21	5.92
.36	.81	1.64	2.42	3.19	3.95	4.71	5.46	6.20
.37	.85	1.71	2.53	3.33	4.13	4.92	5.70	6.48
.38	.88	1.79	2.64	3.48	4.31	5.13	5.95	6.76
.39	.92	1.86	2.75	3.62	4.49	5.35	6.20	7.05
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.55	1.56	3.17	4.71	6.23	7.74	9.25	10.8	12.2
.56	1.61	3.26	4.84	6.41	7.97	9.52	11.1	12.6
.57	1.65	3.35	4.98	6.59	8.20	9.79	11.4	13.0
.58	1.70	3.44	5.11	6.77	8.43	10.1	11.7	13.3
.59	1.74	3.53	5.25	6.96	8.66	10.3	12.0	13.7

Water Measurement Manual

A Water Resources Technical Publication

U.S. Department of the Interior
Bureau of Reclamation
Third edition

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.34	.74	1.50	2.22	2.92	3.61	4.30	4.98	5.66
.35	.78	1.57	2.32	3.05	3.78	4.50	5.21	5.92
.36	.81	1.64	2.42	3.19	3.95	4.71	5.46	6.20
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.41	.99	2.01	2.97	3.92	4.86	5.79	6.72	7.64
.42	1.03	2.09	3.08	4.07	5.05	6.02	6.98	7.94
.43	1.07	2.16	3.20	4.22	5.24	6.25	7.25	8.25
.44	1.11	2.24	3.32	4.38	5.43	6.48	7.52	8.56
.45	1.15	2.32	3.44	4.54	5.63	6.72	7.80	8.87
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.47	1.23	2.48	3.68	4.86	6.03	7.20	8.36	9.51
.48	1.27	2.57	3.80	5.03	6.24	7.45	8.65	9.84
.49	1.31	2.65	3.93	$\boxed{5.19}$	6.45	7.69	8.94	10.2
.50	1.35	2.73	4.05	5.36	6.66	7.95	9.23	10.5
.51	1.39	2.82	4.18	5.53	6.87	8.20	9.53	10.8
.52	1.43	2.90	4.31	5.70	7.08	8.46	9.83	11.2
.53	1.48	2.99	4.44	5.88	7.30	8.72	10.1	11.5
.54	1.52	3.08	4.57	6.05	7.52	8.98	10.4	11.9
.55	1.56	3.17	4.71	6.23	7.74	9.25	10.8	12.2
.56	1.61	3.26	4.84	6.41	7.97	9.52	11.1	12.6
.57	1.65	3.35	4.98	6.59	8.20	9.79	11.4	13.0
.58	1.70	3.44	5.11	6.77	8.43	10.1	11.7	13.3
.59	1.74	3.53	5.25	6.96	8.66	10.3	12.0	13.7

Q = 5.19 cfs

Rating Table = 5.19 cfs
Measured flow (below) = 6.4 cfs
?

- out of level
- water flowing around or underneath
- staff gage improperly set
- submerged condition


Typical Max Flow Determination


1.5’ Parshall Flume
Typical Maximum Flow = 5.1 cfs
high water mark

Free Flow


sub-critical flow
critical flow
super-critical flow
hydraulic jump


Submerged Flow
JUN 2 2004

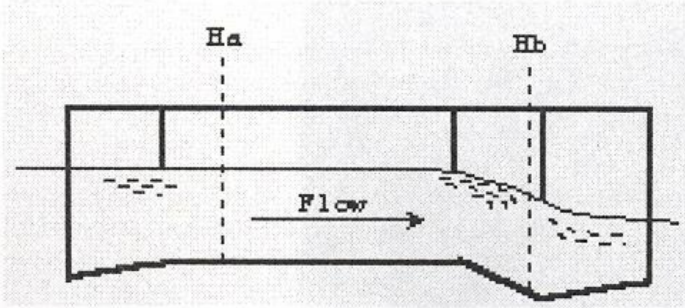


Figure 1

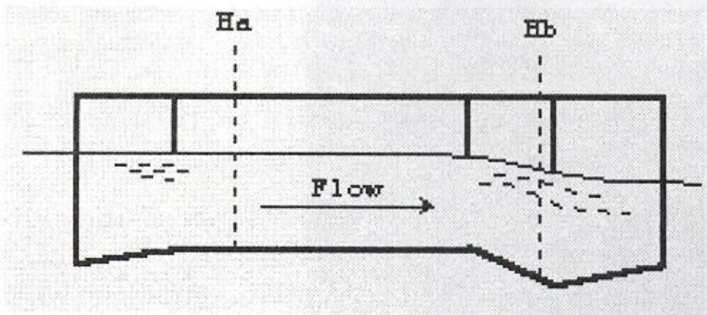


Figure 2

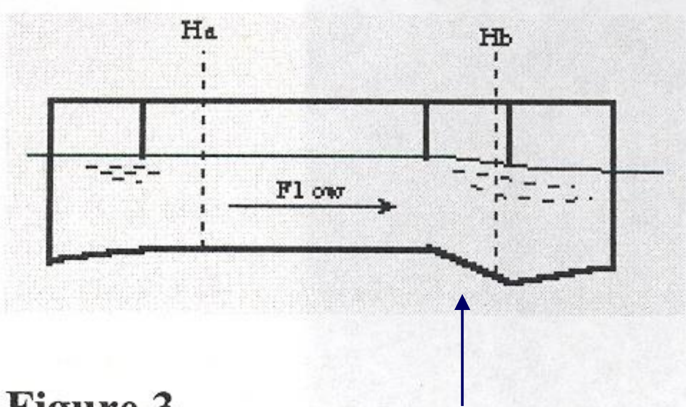


Figure 3

Free Flow

Defn. When the downstream water elevation does not influence flow through the measuring device.

Submerged Flow

Determined by Ratio: H_b/H_a

Defn. Occurs when the downstream elevation of the water surface of the flume or weir is high enough to retard flow.

Submerged Parshall Flume Flow Calculation

University of Wyoming and US Bureau of Reclamation Methods

GIVEN

- 4-foot throat width Parshall Flume
- Flume is level in both directions
- The upstream gage (Ha) reads 0.70 feet
- The flow through the flume appears to be submerged so a downstream gage (Hb) is installed
- The downstream gage (Hb) reads 0.59 feet

SUBMERGENCE DETERMINATION

Submergence is checked by finding the ratio of the downstream head to the upstream head, as shown below.

% submergence = (Hb / Ha) X 100

For our flume, the submergence is:

% submergence = (0.59 / 0.70) X 100
% submergence = **84%**

Since the submergence is greater than 70%, this flow through this flume will have to be calculated as submerged flow. Please note that the % submergence requiring submergence calculations varies with the throat width of the flume. Check Page 13 in the Wyoming manual or Page 8-46 in the *Water Measurement Manual* for the maximum submergence allowed for free flow measurements.

WYOMING METHOD

Go to Figure 23 on Page 65. To use the figure it will be necessary to calculate the difference in the upstream (Ha) and downstream (Hb) heads.

Ha – Hb = 0.70 – 0.59 = **0.11 feet**

As shown in Illustration 1, start at 0.11 feet on the Ha – Hb axis (bottom). Move straight up until the 84% submergence line is met. From the intersection point on the 84% submergence line, move horizontally to the left until the discharge axis (left side) is crossed. Read the flume discharge of 7.95 cfs from the axis. Please note that this chart is valid for only a 4 foot throat Parshall Flume. Other charts, found in the manual, are required for other flume sizes.

Montana Flume (short parshall)

- low head loss requirement
- facilitates sediment
- no approach velocity requirement
- wide range of flows
- easy to build

- cannot measure submergence, must have free flow

Cutthroat Flume

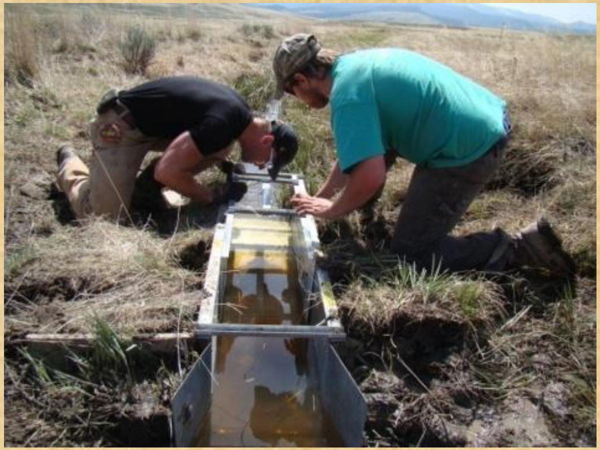
- flat bottom
- easy installation
- less expensive than parshalls
- easy to construct
- variable hydraulic conditions
- difficult to tell submergence


Submerged Flow

Long Throated Flumes

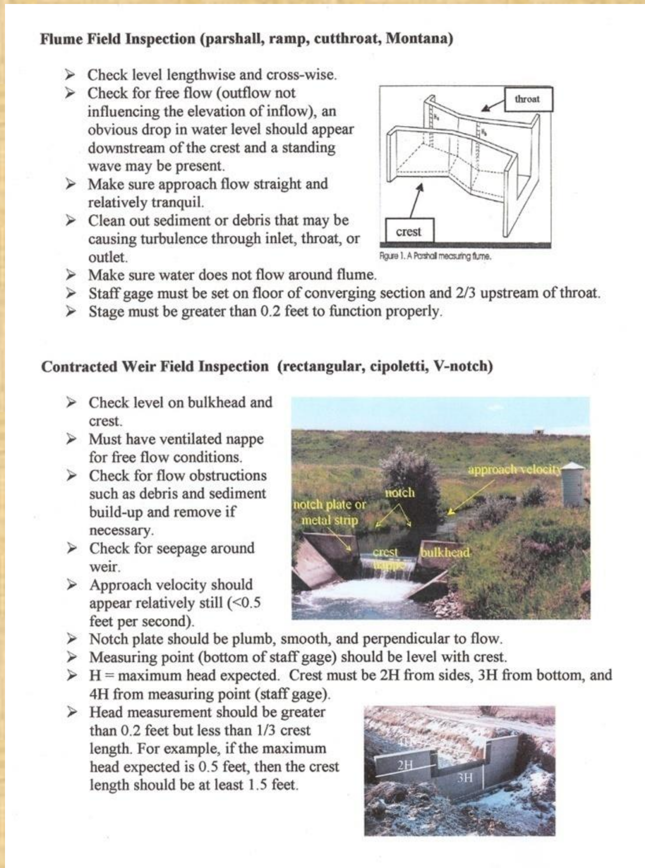
Ramp Flume
Replogle Flume
Broad-Crested Weir
(very similar)

Long-Throated Flumes



Flume Inspection

- ➢ Correct flume size
- ➢ Check for free flow (no submergence)
- ➢ Floor of converging section (crest) is level crosswise and lengthwise
- ➢ Staff gage is placed properly
- ➢ Check for seepage
- ➢ Clear of debris



Flume Field Inspection (parshall, ramp, cutthroat, Montana)

- ➢ Check level lengthwise and cross-wise.
- ➢ Check for free flow (outflow not influencing the elevation of inflow), an obvious drop in water level should appear downstream of the crest and a standing wave may be present.
- ➢ Make sure approach flow straight and relatively tranquil.
- ➢ Clean out sediment or debris that may be causing turbulence through inlet, throat, or outlet.
- ➢ Make sure water does not flow around flume.
- ➢ Staff gage must be set on floor of converging section and 2/3 upstream of throat.
- ➢ Stage must be greater than 0.2 feet to function properly.

Figure 1. A Parshall measuring flume.

Contracted Weir Field Inspection (rectangular, cipoletti, V-notch)

- ➢ Check level on bulkhead and crest.
- ➢ Must have ventilated nappe for free flow conditions.
- ➢ Check for flow obstructions such as debris and sediment build-up and remove if necessary.
- ➢ Check for seepage around weir.
- ➢ Approach velocity should appear relatively still (<0.5 feet per second).
- ➢ Notch plate should be plumb, smooth, and perpendicular to flow.
- ➢ Measuring point (bottom of staff gage) should be level with crest.
- ➢ H = maximum head expected. Crest must be 2H from sides, 3H from bottom, and 4H from measuring point (staff gage).
- ➢ Head measurement should be greater than 0.2 feet but less than 1/3 crest length. For example, if the maximum head expected is 0.5 feet, then the crest length should be at least 1.5 feet.


Common Issues with Flumes
Old

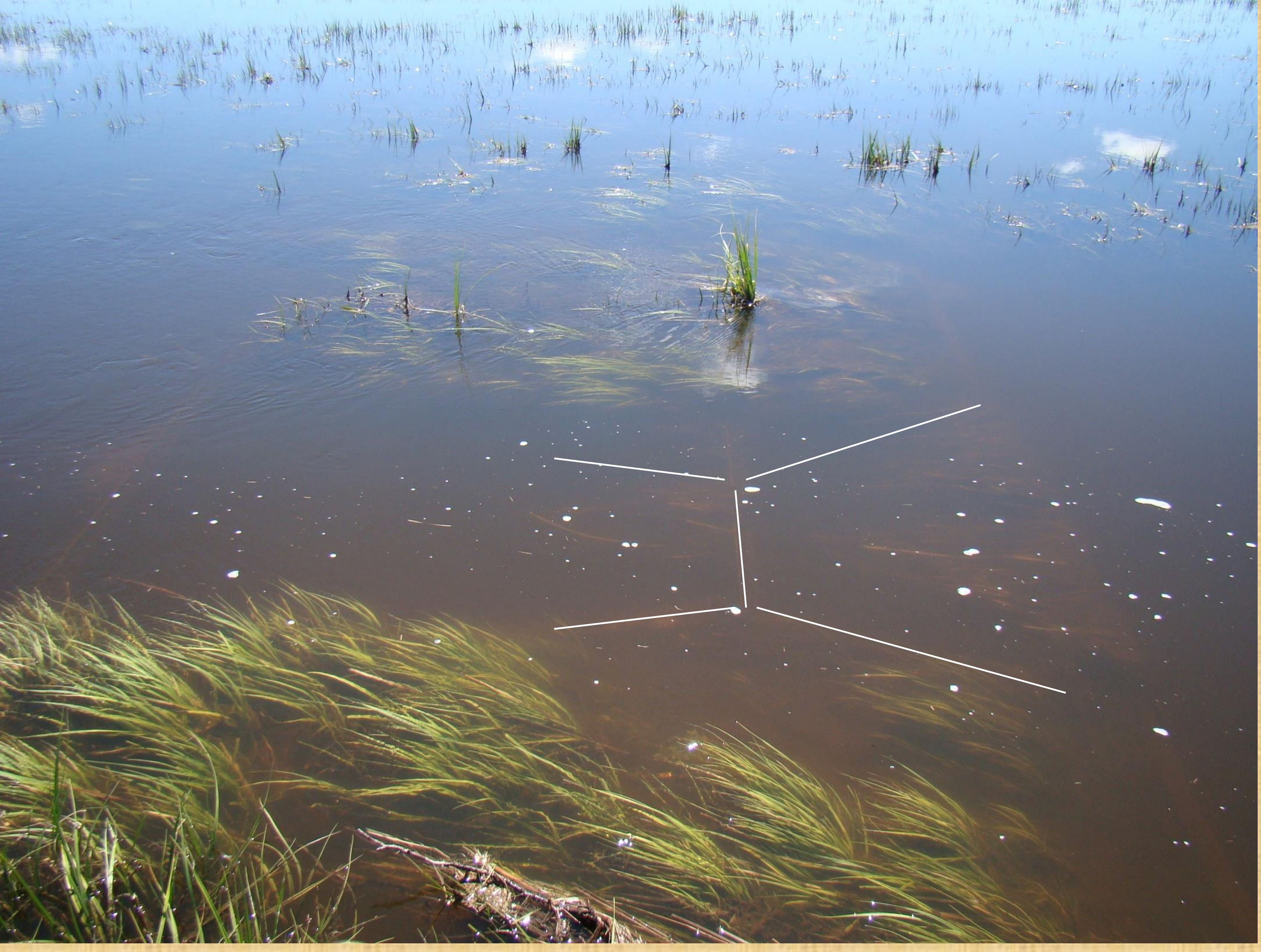
Too close to headgate – turbulence, uneven flow

Too Close to Headgate?

- Flume floor must be below elevation of headgate or diversion dam.

- Flat ditches (low head loss)

Too close to downstream culvert



Too Far?

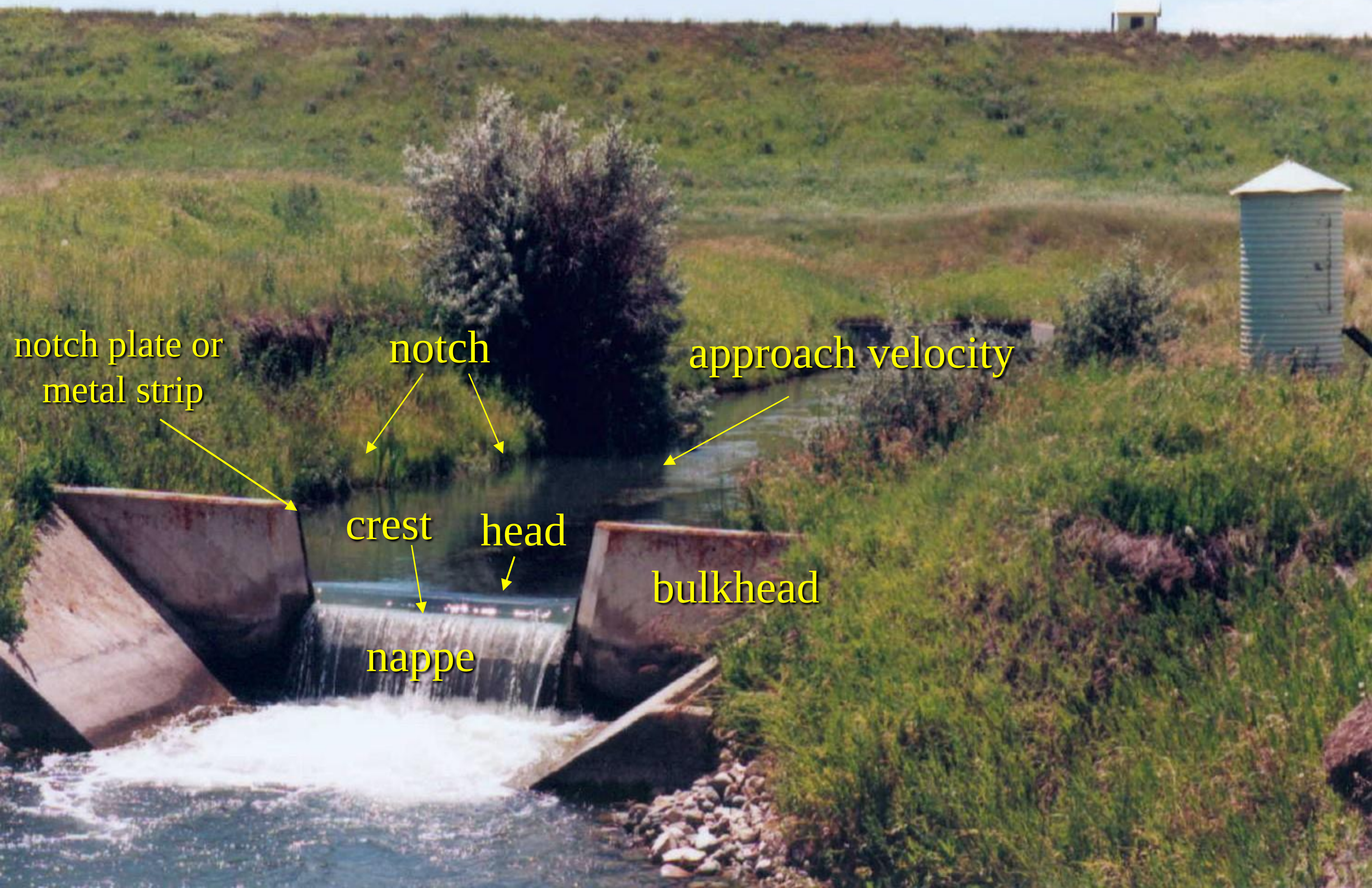

Location of original measuring device
ditch
scale 1 mile = 3.5 "
Pointof Diversion


New Measuring Device
Point of Diversion

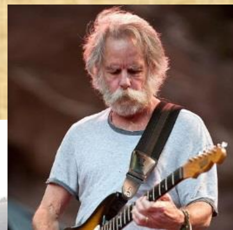

Out of Level?

Weirs

Overflow structure installed perpendicular to flow



Weir vs. Flume



- head loss requirement (flume = 25% * weir)
- weirs have approach velocity requirement
- weirs can be easier to build
- weirs can collect sediment and debris

  (require more maintenance)

Sharp-Crested Weir

3 Standard Types

Contracted Rectangular

Cipolletti Contracted

Contracted Triangular or V-Notch

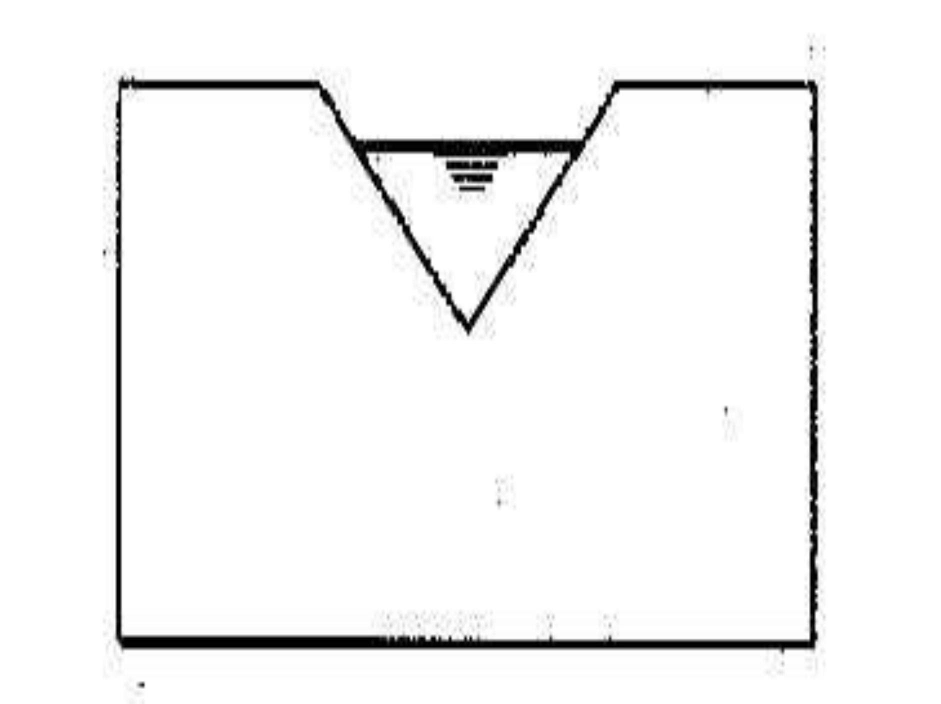
Sharp-Crested Weir

Contracted Rectangular

Sharp Crested Weir

Cipolletti Contracted - Trapezoidal in shape with sides that incline outwardly at a slope of 1 horizontal to 4 vertical. May be more accurate at lower stages than rectangular weir.

Sharp Crested Weir

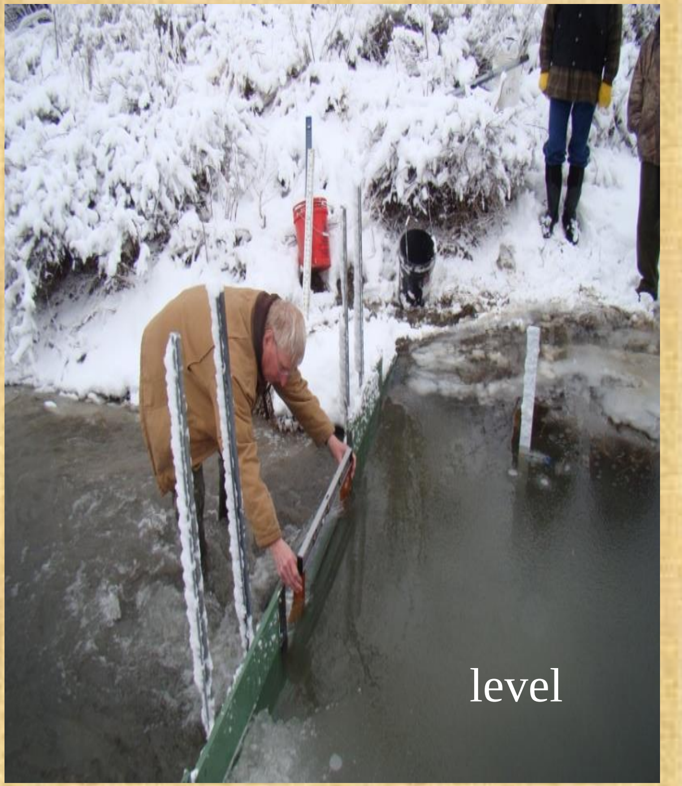


Contracted Triangular or V-Notch

Measures flows up to 4.3 cfs or 1.25 feet of head

Conditions needed for all types of Sharp-Crested Weirs

- Weir should be installed in straight section of ditch/canal.
- Upstream face of the weir plates and bulkhead should be plumb, smooth, and normal to the axis of the channel.
- Approach velocity <= 0.5 feet/second (appear still).




APR 7 2004


ventilated nappe
APR 7 2004

Weir Installation Specifications

Accurate Water Measurement is dependent on:

- Measuring device selection
- Installation
- Correct use of measuring device
- Maintenance and quality control

Using your Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.

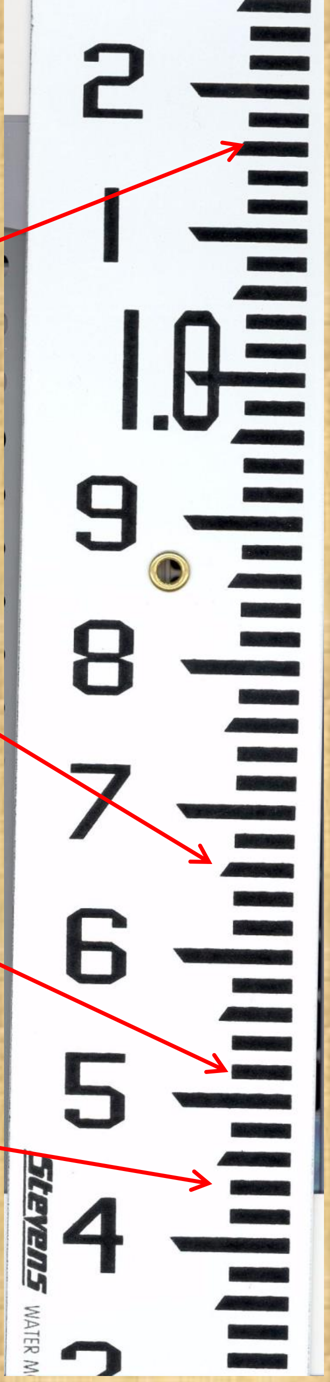
1) Parshall flume, throat width = 5 feet, gage reading

2) Montana Flume, throat width = 2.5 feet, gage reading

3) Cipoletti weir, crest length = 5 feet, gage reading

4) V-notch weir, gage reading

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet



Using your favorite Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.

1) Parshall flume, throat width = 5 feet, gage reading

gh = 1.16, Q = 25.3 cfs

2) Montana Flume, throat width = 2.5 feet, gage reading

3) Cipoletti weir, crest length = 5 feet, gage reading

4) V-notch weir, gage reading

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet

Using your favorite Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.

1) Parshall flume, throat width = 5 feet, gage reading

gh = 1.16’ Q = 25.3 cfs

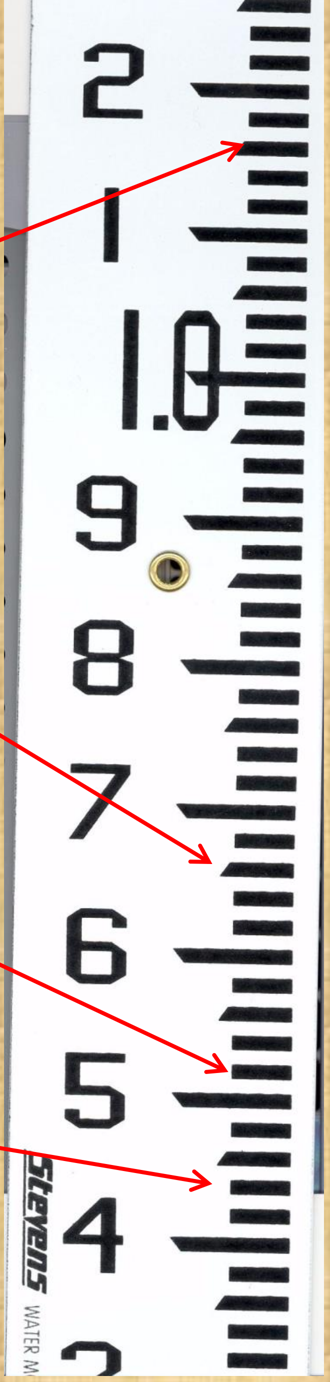
2) Montana Flume, throat width = 2.5 feet, gage reading

gh = 0.65’ Q = 5.11 cfs

3) Cipoletti weir, crest length = 5 feet, gage reading

4) V-notch weir, gage reading

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet



Using your favorite Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.

1) Parshall flume, throat width = 5 feet, gage reading

gh = 1.16’ Q = 25.3 cfs

2) Montana Flume, throat width = 2.5 feet, gage reading

gh = 0.65’ Q = 5.11 cfs

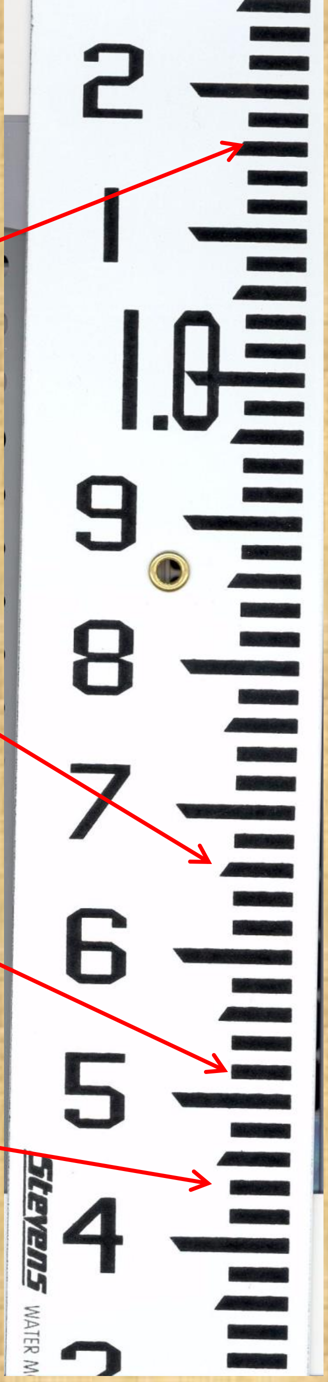
3) Cipoletti weir, crest length = 5 feet, gage reading

gh = 0.51’ Q = 6.13 cfs

4) V-notch weir, gage reading

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet

Using your favorite Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.



1) Parshall flume, throat width = 5 feet, gage reading

gh = 1.16’ Q = 25.3 cfs

2) Montana Flume, throat width = 2.5 feet, gage reading

gh = 0.65’ Q = 5.11 cfs

3) Cipoletti weir, crest length = 5 feet, gage reading

gh = 0.51’ Q = 6.13 cfs

4) V-notch weir, gage reading

gh = 0.43’ Q = 0.31 cfs

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet

Using your favorite Irrigation Water Measurement Guide, determine flow in cfs for the following measuring devices.

1) Parshall flume, throat width = 5 feet, gage reading
gh = 1.16’ Q = 25.3 cfs

2) Montana Flume, throat width = 2.5 feet, gage reading
gh = 0.65’ Q = 5.11 cfs

3) Cipoletti weir, crest length = 5 feet, gage reading

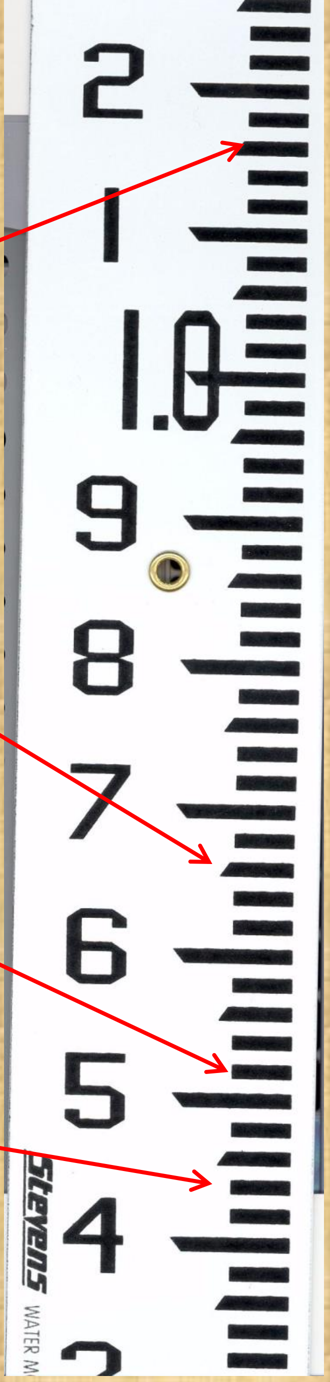
gh = 0.51’ Q = 6.13 cfs

4) V-notch weir, gage reading

gh = 0.43’ Q = 0.31 cfs

5) Parshall flume, throat size = 12 feet, gage reading = 0.05 feet

flow too low to accurately measure



Most Common Ditch/Canal Measuring Devices in Montana

If properly installed, maintained and operated, the following are acceptable measuring devices for Water Commissioners:

<u>Flumes</u>

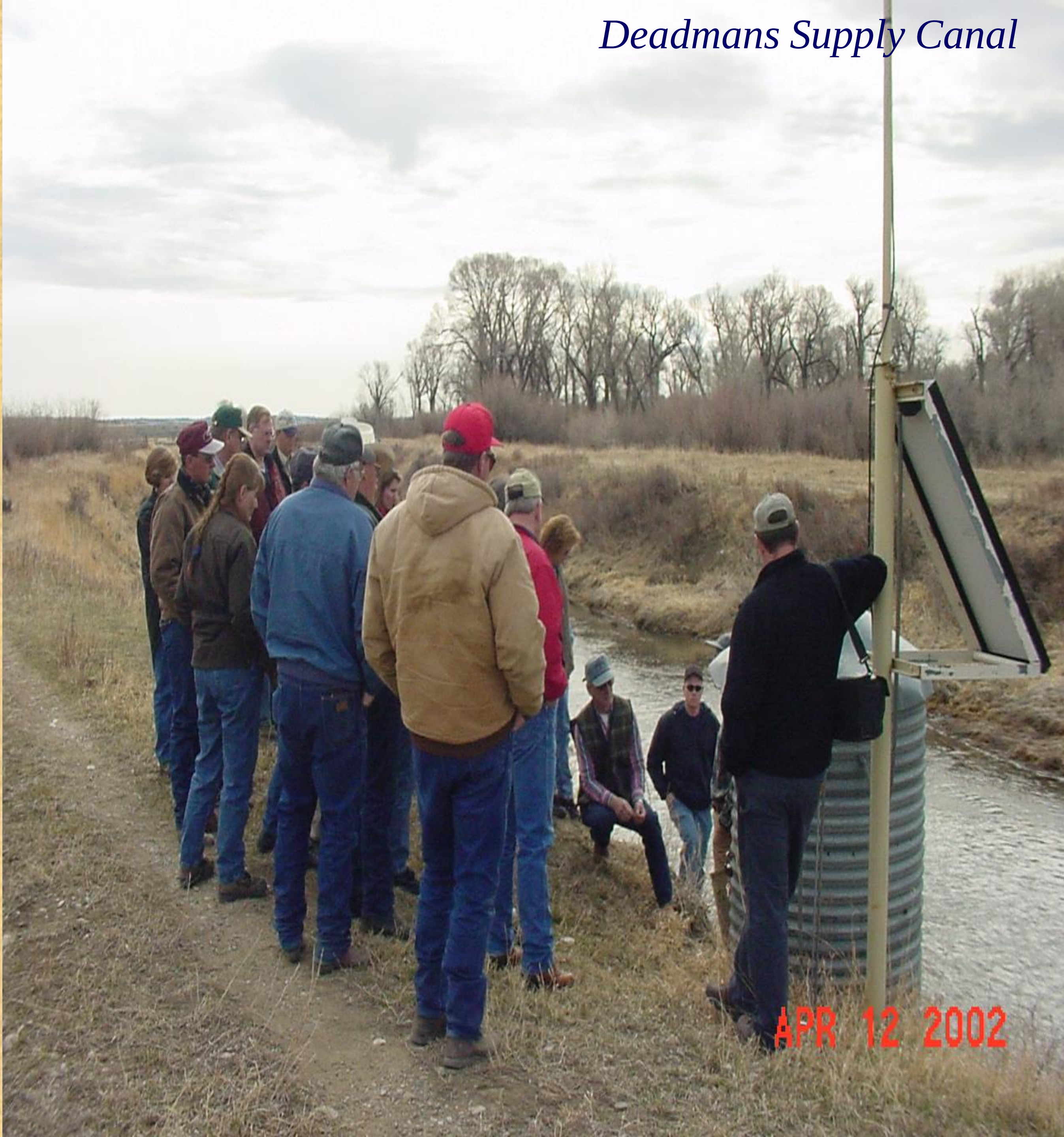
Parshall
Montana
Ramp
Cutthroat

<u>Weirs</u>

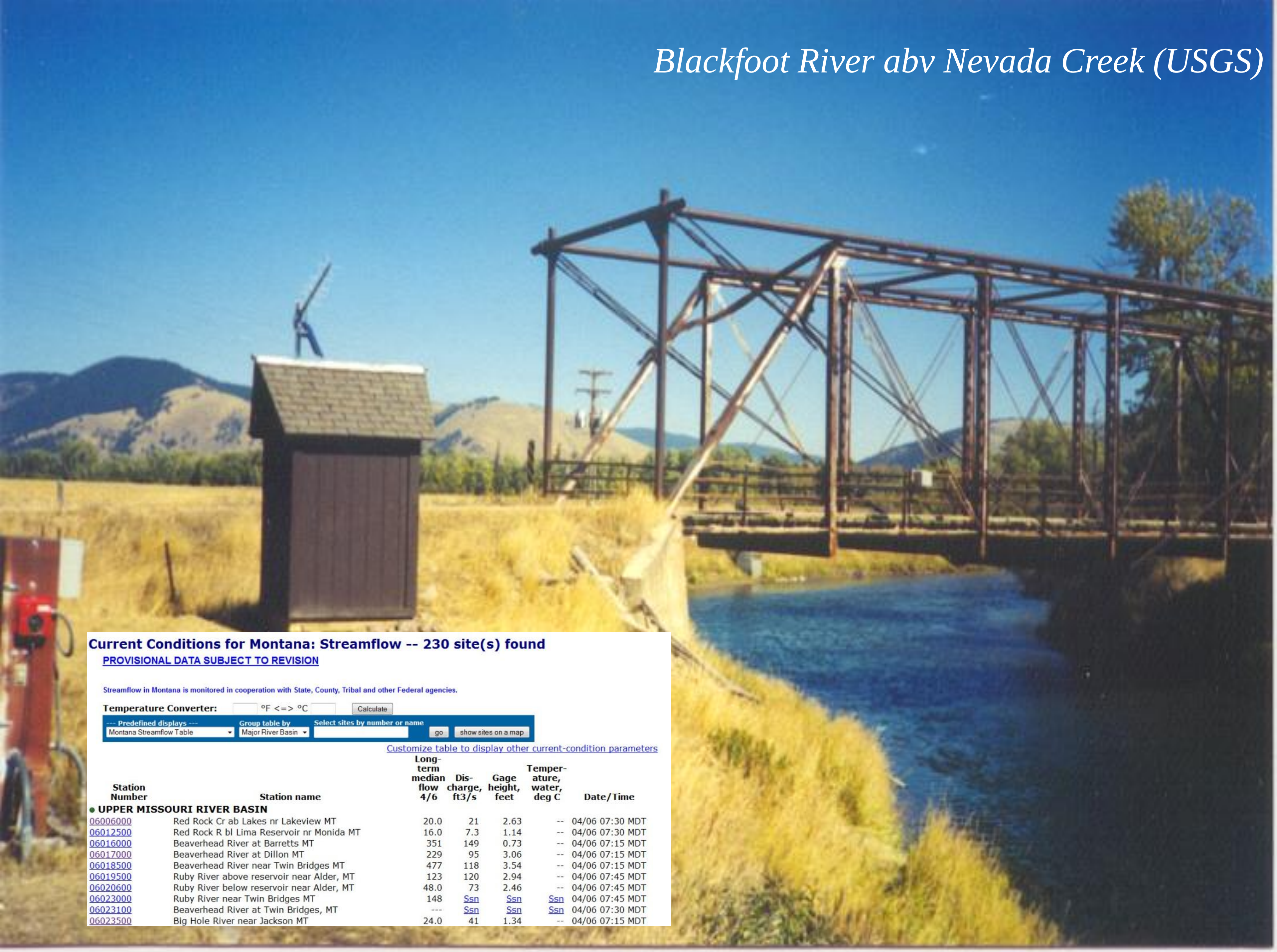
Contracted rectangular
Cipolleti
V-Notch

Automated Devices

Streamflow Gaging Stations



Blackfoot River abv Nevada Creek (USGS)



Current Conditions for Montana: Streamflow -- 230 site(s) found

PROVISIONAL DATA SUBJECT TO REVISION

Streamflow in Montana is monitored in cooperation with State, County, Tribal and other Federal agencies.

Temperature Converter: °F <=> °C Calculate

--- Predefined displays --- Montana Streamflow Table | Group table by Major River Basin | Select sites by number or name | go | show sites on a map

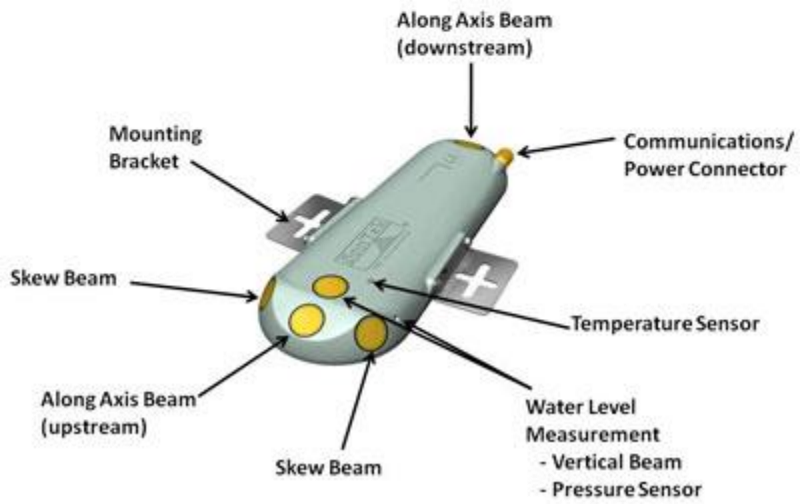
Customize table to display other current-condition parameters

Station Number	Station name	Long-term median flow 4/6	Dis-charge, ft3/s	Gage height, feet	Temper-ature, water, deg C	Date/Time
● UPPER MISSOURI RIVER BASIN						
06006000	Red Rock Cr ab Lakes nr Lakeview MT	20.0	21	2.63	--	04/06 07:30 MDT
06012500	Red Rock R bl Lima Reservoir nr Monida MT	16.0	7.3	1.14	--	04/06 07:30 MDT
06016000	Beaverhead River at Barretts MT	351	149	0.73	--	04/06 07:15 MDT
06017000	Beaverhead River at Dillon MT	229	95	3.06	--	04/06 07:15 MDT
06018500	Beaverhead River near Twin Bridges MT	477	118	3.54	--	04/06 07:15 MDT
06019500	Ruby River above reservoir near Alder, MT	123	120	2.94	--	04/06 07:45 MDT
06020600	Ruby River below reservoir near Alder, MT	48.0	73	2.46	--	04/06 07:45 MDT
06023000	Ruby River near Twin Bridges MT	148	Ssn	Ssn	Ssn	04/06 07:45 MDT
06023100	Beaverhead River at Twin Bridges, MT	---	Ssn	Ssn	Ssn	04/06 07:30 MDT
06023500	Big Hole River near Jackson MT	24.0	41	1.34	--	04/06 07:15 MDT

Continuous Water Level Sensors

- TruTracks
- Pressure Transducers

Bottom Mounted Doppler Meters



In-Line Meters and Flow Totalizers

Ultra-Sonic Meters

Weir Sticks

• Commercially calibrated stick that shows depth of flow plus velocity head when placed on weir crest. In this case velocity head would be equal to the run up of water on the stick (Clausen Rule)

• May be calibrated to be read at an angle.

<u>Open channel measuring device selection:</u> Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load.

2) High sediment load, trapezoidal ditch, potential for submerged conditions.

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs.

4) Low head loss, moderate to high sediment load, wide range of flows.

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible.

6) Water right is contract water that is administered based on volume.

7) A ditch has a number of standard outlets through pipe conduits.

8) DNRC hydrologist is on-site and you want to check accuracy of your weir.

Open channel measuring Device Selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load. **weir**

2) High sediment load, trapezoidal ditch, potential for submerged conditions.

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs.

4) Low head loss, moderate to high sediment load, wide range of flows.

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible.

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Open channel measuring Device Selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load. weir

2) High sediment load, trapezoidal ditch, potential for submerged conditions. **broad-crested weir or ramp flume**

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs.

4) Low head loss, moderate to high sediment load, wide range of flows.

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible.

6) Water right is contract water that is administered based on volume.

7) A ditch has a number of standard outlets through pipe conduits.

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<u>Open channel measuring Device Selection:</u> Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load. weir

2) High sediment load, trapezoidal ditch, potential for submerged conditions. broad-crested weir or ramp flume

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs. **V-notch or small rectangular weir**

4) Low head loss, moderate to high sediment load, wide range of flows.

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible.

6) Water right is contract water that is administered based on volume.

7) A ditch has a number of standard outlets through pipe conduits.

8) DNRC hydrologist is on-site and you want to check accuracy of your weir.

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2) High sediment load, trapezoidal ditch, potential for submerged conditions. broad-crested weir or ramp flume

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs. V-notch or small rectangular weir

4) Low head loss, moderate to high sediment load, wide range of flows. flume

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible.

6) Water right is contract water that is administered based on volume.

7) A ditch has a number of standard outlets through pipe conduits

8) DNRC hydrologist is on-site and you want to check accuracy of your weir.

Open channel measuring Device Selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load. weir

2) High sediment load, trapezoidal ditch, potential for submerged conditions. broad-crested weir or ramp flume

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs. V-notch or small rectangular weir

4) Low head loss, moderate to high sediment load, wide range of flows. flume

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible. **bucket, stop watch**

6) Water right is contract water that is administered based on volume.

7) A ditch has a number of standard outlets through pipe conduits.

8) DNRC hydrologist is on-site and you want to check accuracy of your weir.

Open channel measuring Device Selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load. weir

2) High sediment load, trapezoidal ditch, potential for submerged conditions. broad-crested weir or ramp flume

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs. V-notch or small rectangular weir

4) Low head loss, moderate to high sediment load, wide range of flows. flume

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible. bucket, stop watch

6) Water right is contract water that is administered based on volume. **flume with totalizer**

7) A ditch has a number of standard outlets through pipe conduits.

8) DNRC hydrologist is on-site and you want to check accuracy of your weir.

Open channel measuring Device Selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load. weir

2) High sediment load, trapezoidal ditch, potential for submerged conditions. broad-crested weir or ramp flume

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs. V-notch or small rectangular weir

4) Low head loss, moderate to high sediment load, wide range of flows. flume

5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible. bucket, stop watch

6) Water right is contract water that is administered based on volume. flume, totalizer

7) A ditch has a number of standard outlets through pipe conduits. **portable propeller, ultra sonic meter**

8) DNRC hydrologist is on-site and you want to check accuracy of your weir.

Open channel measuring Device Selection: Choose the type of measuring device you the water commissioner would most likely recommend under the following conditions.

1) Moderate to high head loss, low sediment load. weir

2) High sediment load, trapezoidal ditch, potential for submerged conditions. broad-crested weir or ramp flume

3) Need to measure seepage below a dam. Expected flows 0.5-2 cfs. V-notch or small rectangular weir

4) Low head loss, moderate to high sediment load, wide range of flows. flume

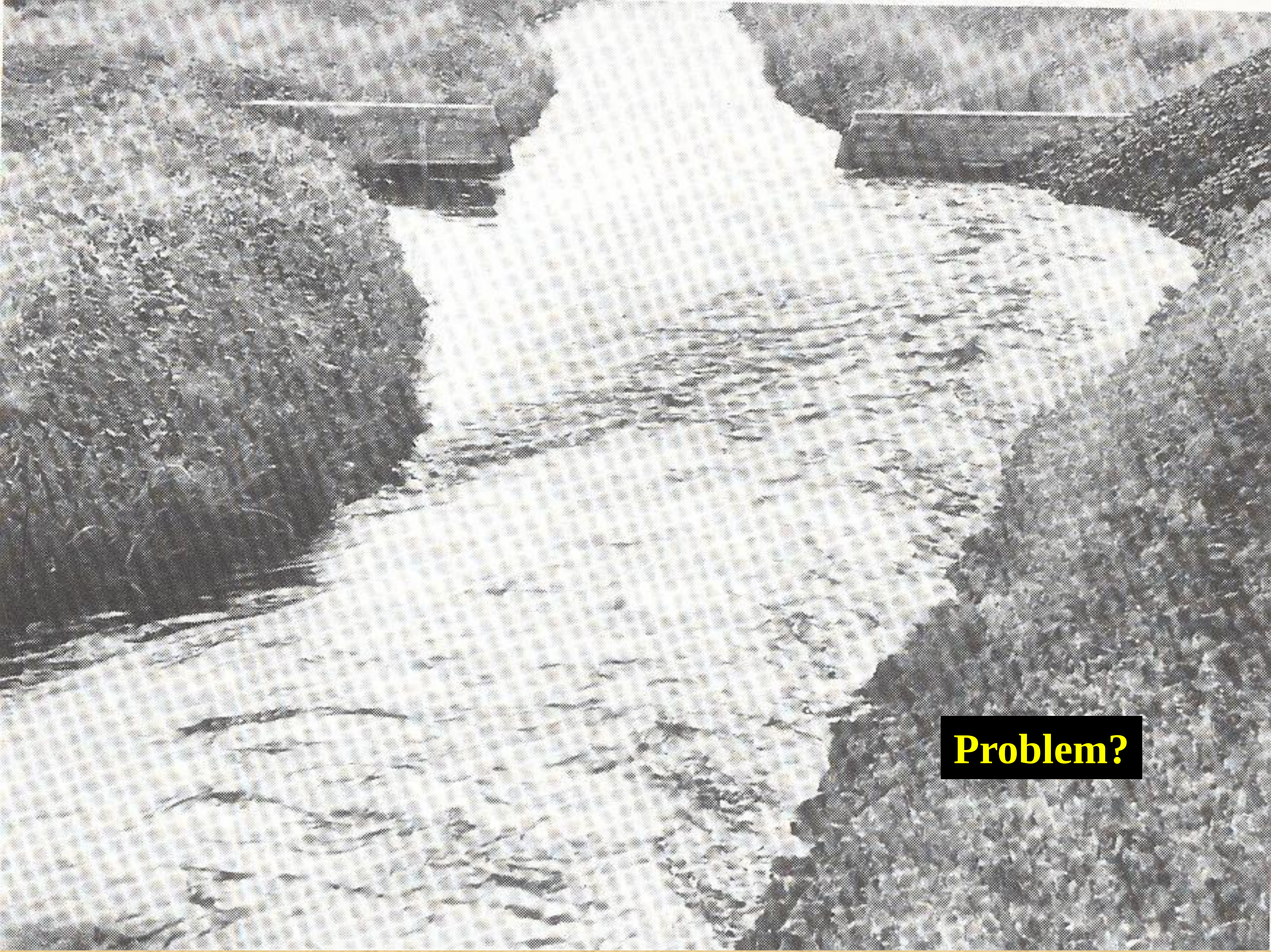
5) Point of diversion is small discharge (<25 gpm) from a pipe that is easily accessible. bucket, stop watch

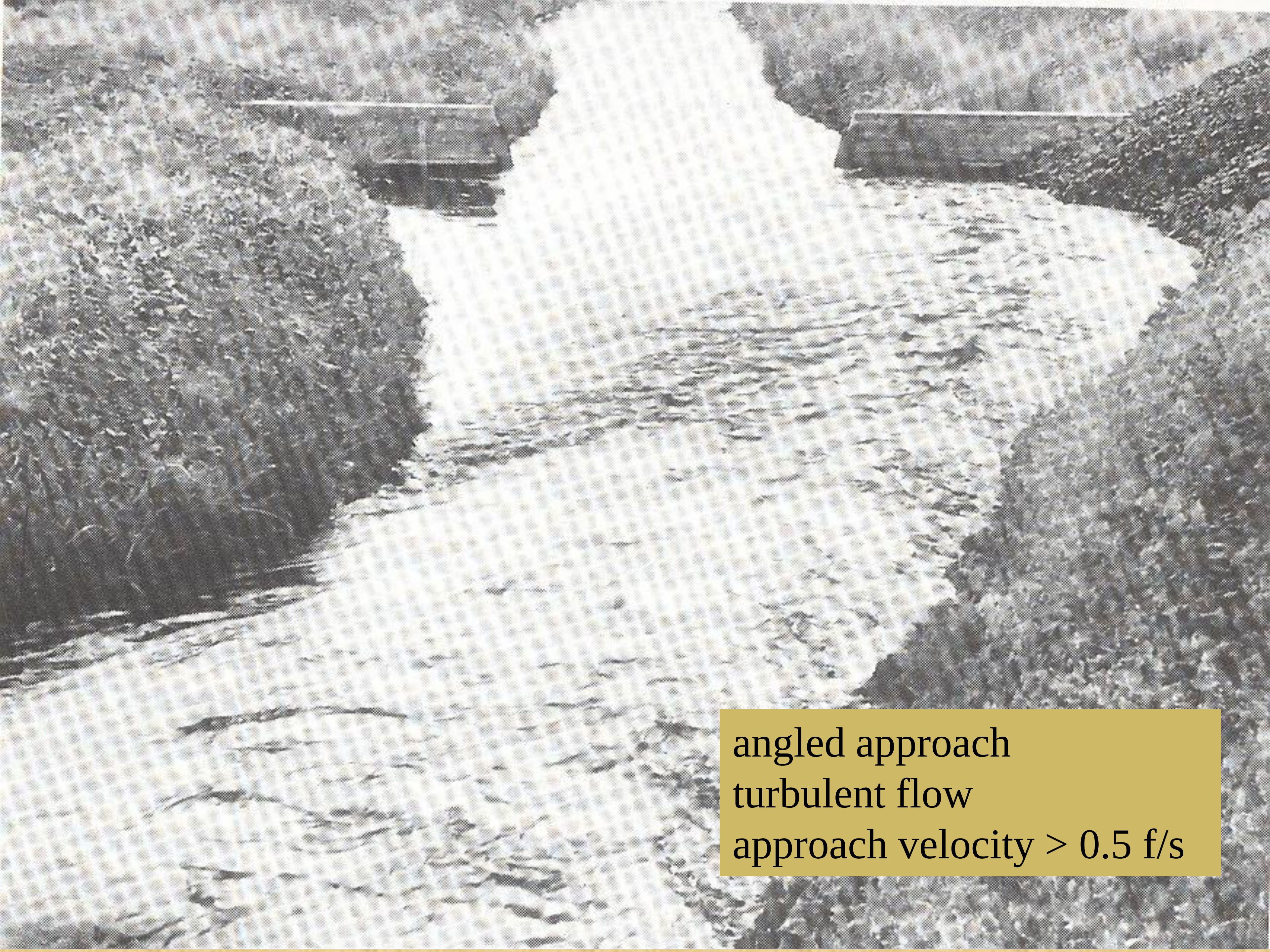
6) Water right is contract water that is administered based on volume. flume, rated section, totalizer

7) A ditch has a number of standard outlets through pipe conduits. portable propeller, ultra sonic meter

8) DNRC hydrologist is on-site and you want to check accuracy of your weir. current meter

More
Visual Examples


Problem?



angled approach
turbulent flow
approach velocity > 0.5 f/s

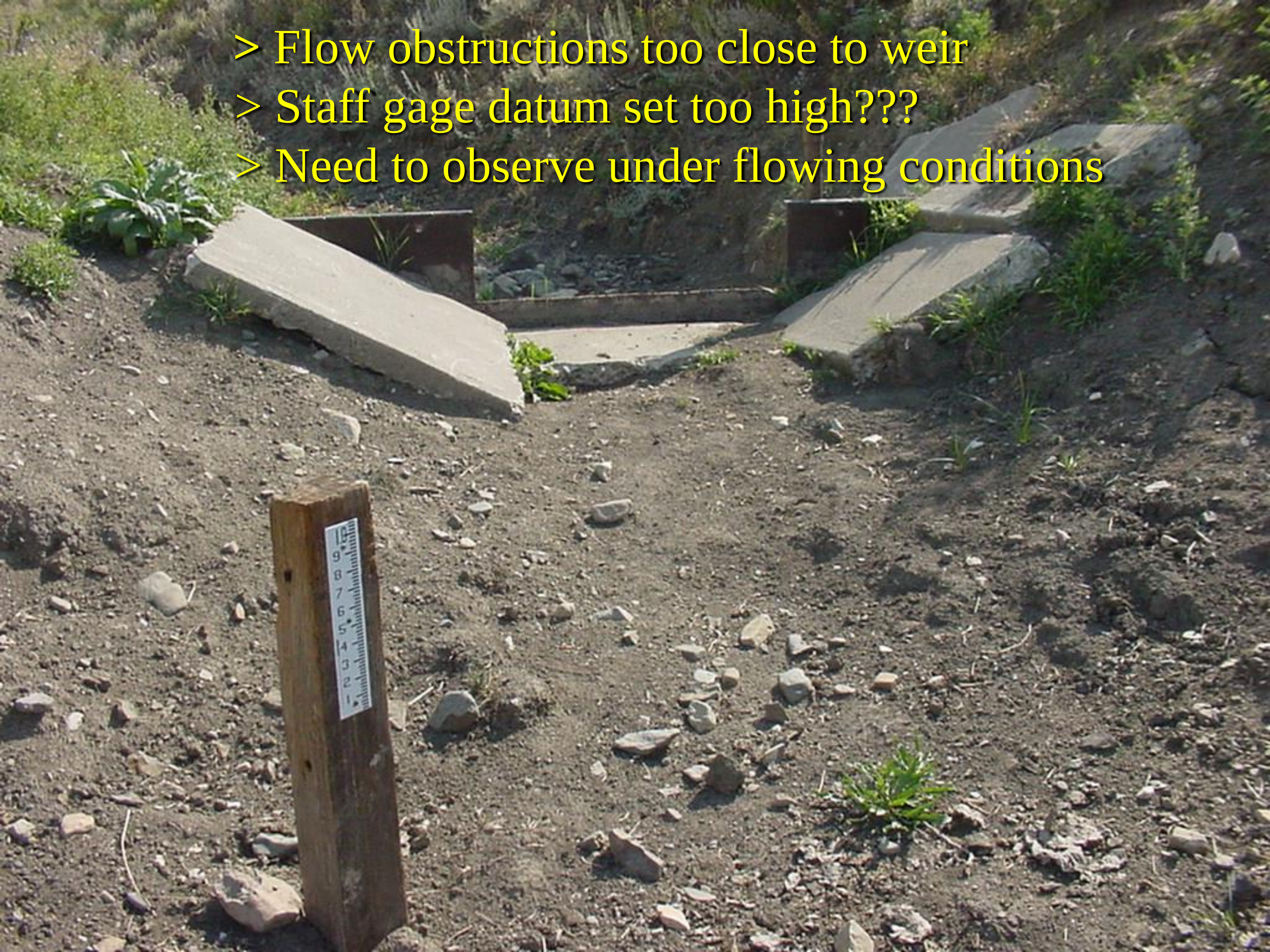

05/07/2014

Problem?


APR 12 2002
> Staff gage not level with weir crest
> Crest not level


proper location = 2/3 from throat


10
9
8
7
6
5
4
3
2
1


> Flow obstructions too close to weir
> Staff gage datum set too high???
> Need to observe under flowing conditions


MAR 30 2004


Needs:
• cleaning
• clearing of debris
MAR 30 2004


Good location
Proper sizing
JUN 2 2004


Submerged Flow
No hydraulic jump
Needs Re-setting
JUN 2 2004

3' Parshall Flume


Flow direction?
Over- or underestimating flow?


Submerged Flow
Needs Re-setting

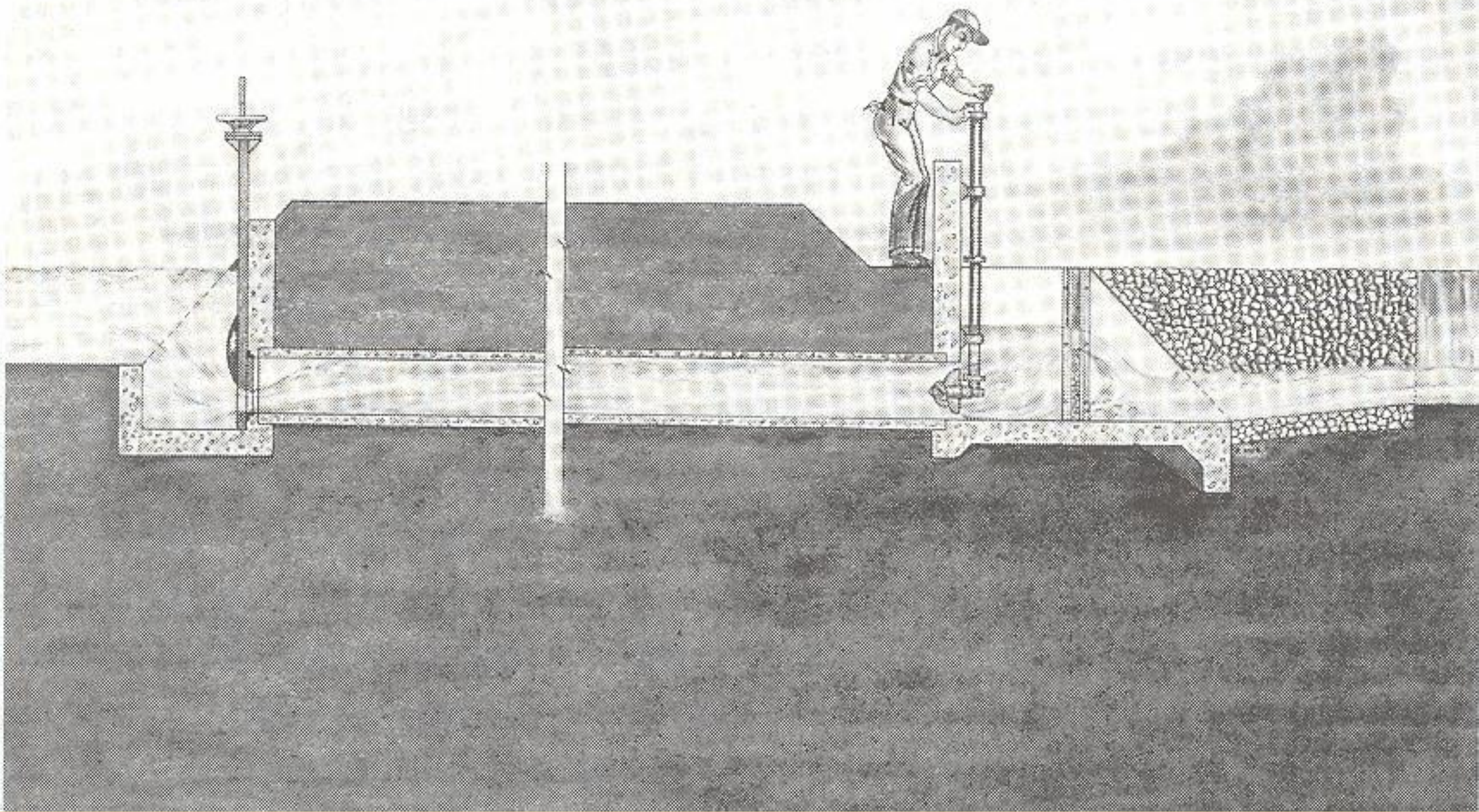

06/17/2008


Problem??
5 29 '03


Poor Sizing
Submerged Flow
Downstream checks?
5 29 '03

Closed Conduit Flow

Culvert Measurements and Closed Conduit Flow




CUBIC FEET PER SECOND


BLUE-WHITE® INDUSTRIES
MODE RESET
GALLONS PER MINUTE
Rate - Totalizer
F-1000-RT

EC 1369 • Reprinted September 1994

Estimating Water Flow Rates

W.L. Trimmer

Increasing competition for water resources has made water conservation a high priority. Measuring the flow rate of water is the first step to good water management. All water right holders in the State of Oregon must be able to measure the flow rate of the water being diverted.

If a flow meter, flume, or weir isn't available, there are several methods available to estimate flow rate that you can do with available tools like stopwatches, rulers, and buckets.

The usual unit measuring flow rate for irrigation water rights is a cubic foot per second (cfs). This is water flowing through a cross-sectional area of 1 ft^2 at a velocity of 1 foot per second, and it's sometimes called a second-foot.

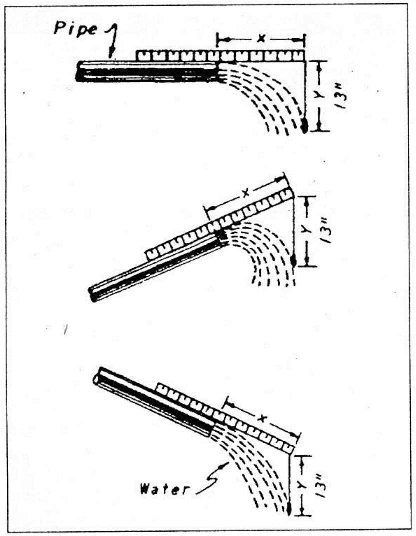


Figure 1.—Measuring horizontal distance (X) of a pipe flowing full with vertical drop Y=13".

A common diversion rate in eastern Oregon might be 1 cfs/40 acres. Here are some handy conversions (see page 4 for others): 1 cfs is about 450 gallons per minute; 1 cfs is about 1 acre-inch per hour; 1 cfs is about 2 acre-feet per day.

Propeller flow meters, weirs, and flumes provide the most accurate measures of flow rate, but in many instances you must make an estimate without them. Here are four methods to estimate irrigation diversions.

Method 1
Discharge from a pipe

If water can freely drop from a pipe, you can estimate the flow rate by measuring length with nothing more than a carpenter's rule. When the pipe is flowing full, place the rule as shown in Figure 1 and measure a horizontal distance when the vertical drop Y = 13 inches.

Find the proper pipe size in Table 1, and the discharge is in gallons per minute (gpm). If the pipe isn't level, use a plumb bob to measure the vertical drop Y.

Example 1. An 8-inch-diameter pipe is flowing full, and the horizontal distance X is measured to be 20 inches. From Table 1, the flow rate is 1,005 gpm.

If the pipe is flowing only partially full, find the ratio of the unfilled portion of pipe to the diameter of the pipe to estimate flow rate in gallons per minute, as shown in Table 2.

Example 2. A 10-inch-diameter pipe is flowing only partially full. The measured distance U is 2 inches. The ratio U ÷ D in Table 2 is 2 ÷ 10 = 0.2. The flow rate is 825 gpm.

Walter L. Trimmer, former Extension irrigation specialist, Oregon State University.

OREGON STATE UNIVERSITY EXTENSION SERVICE

Table 1.—Discharge (gallons per minute) from pipes flowing full, with vertical drop Y = 13" and variable horizontal distances X.

Pipe size		Horizontal distance X (in inches)												
Inside diam.	Area (sq in)	12	14	16	18	20	22	24	26	28	30	32	34	36
2.0	3.14	38	44	50	57	63	69	75	82	88	94	100	107	113
2.5	4.91	59	69	79	88	98	108	118	128	137	147	157	167	177
3.0	7.07	85	99	113	127	141	156	170	184	198	212	226	240	255
4.0	12.57	151	176	201	226	251	277	302	327	352	377	402	427	453
5.0	19.64	236	275	314	354	393	432	471	511	550	589	628	668	707
6.0	28.27	339	396	452	509	565	622	678	735	792	848	905	961	1013
7.0	38.48	462	539	616	693	770	847	924	1000	1077	1154	1231	1308	1385
8.0	50.27	603	704	804	905	1005	1106	1206	1307	1408	1508	1609	1709	1810
9.0	63.62	763	891	1018	1145	1272	1400	1527	1654	1781	1909	2036	2163	2290
10.0	78.54	942	1100	1257	1414	1471	1728	1885	2042	2199	2356	2513	2670	2827
11.0	95.03	1140	1330	1520	1711	1901	2091	2281	2471	2661	2851	3041	3231	3421
12.0	113.10	1357	1583	1809	2036	2262	2488	2714	2941	3167	3393	3619	3845	4072

$Q = \frac{3.61\,AX}{\sqrt{Y}}$, where:
A = Cross-sectional area of discharge pipe in square inches
X = Horizontal distance in inches
Y = Vertical distance in inches

Table 2.—An approximate method of estimating discharge from pipes flowing partially full.

	Inside diameter of pipe = D in inches				
$\frac{U}{D}$	4	6	8	10	12
0.1	142	334	379	912	1310
0.2	128	302	524	825	1185
0.3	112	264	457	720	1034
0.4	94	222	384	605	868
0.5	75	176	305	480	689
0.6	55	130	226	355	510
0.7	37	88	152	240	345
0.8	21	49	85	134	194
0.9	8	17	30	52	74
1.0	0	0	0	0	0


Looks level to me, what do you think?
Questions??

Manual Measurements

-Current meters

- Float-area method

Current Meters

Classes of current meters

- Mechanical: Anemometer and propeller velocity meters
  (not discussed)
- Electromagnetic velocity meters
- Doppler velocity meters

Current Meters

- Electromagnetic

Example: Marsh-McBirney Velocity Meter with digital read-out

Current meter probe produces a magnetic field, water moving through that field generates a voltage which is proportional to the velocity of the water

Current Meters

Maintenance (Marsh-McBirney)

- zero test every two weeks (depending on usage) or prior to going to field
- clean probe when necessary (400-600 grit sandpaper)
- May need laboratory calibration

Doppler-Style Current Meters

Example: Flow-Tracker Acoustic Doppler Meter

- Sound is generated by transmitter
- Sound bounces off suspended particles in the water
- Doppler effect is used to compute velocity

Meter Transmitter

Keypad and Discharge Computer

Doppler-Style Current Meters

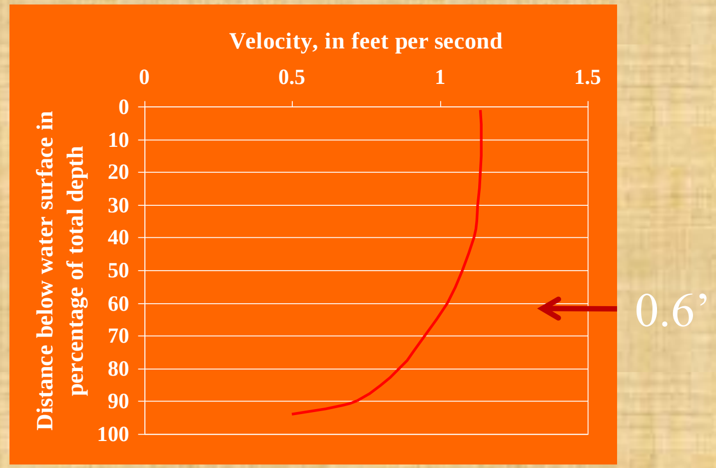
Acoustic Doppler Current Profiler (ADCP)

Measuring Flow with Current Meters

- Current meters measure velocity at a point.
- USGS Methodology

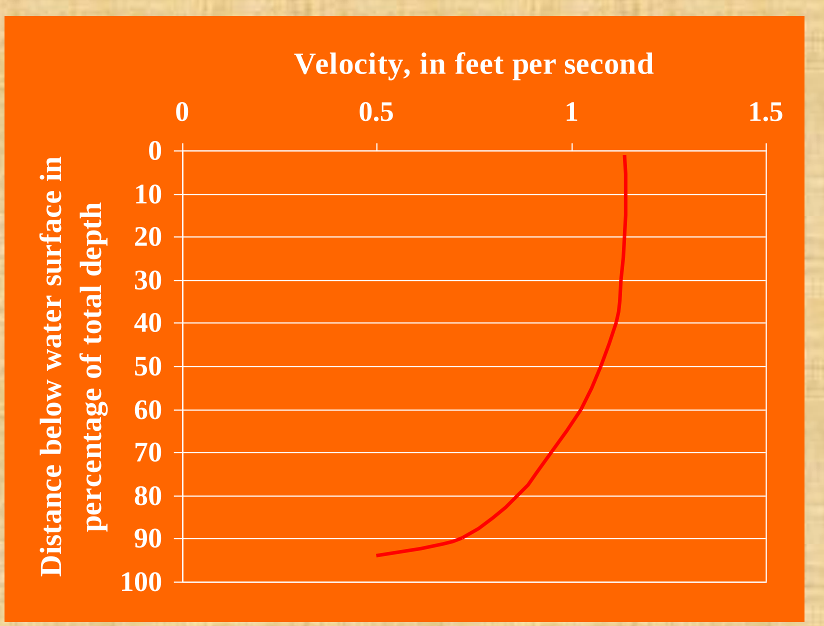
  (Rantz, 1982 USGS WSP 2175
  Nolan and Shields WRI 00-4036)
- Typically 20 points across section
  Accuracy Goal per section = 5%
  Re-measure if > 10%
- Meter is placed six-tenths depth from the surface (mean V)
- 40 second intervals

Livermore Creek near Browning



Measuring Flow with Current Meters

- If depth greater than 2.5 feet, 2-point measurement
  - average 0.2 and 0.8 depths
- If velocity profile is “abnormal”, 3-point measurement
  - average 0.6 with average of 0.2 and 0.8



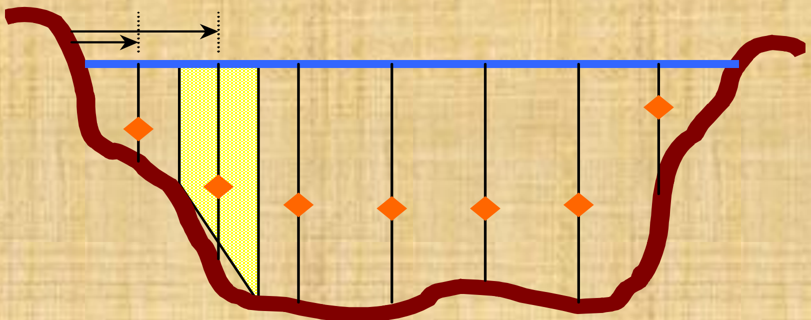
Current Meters

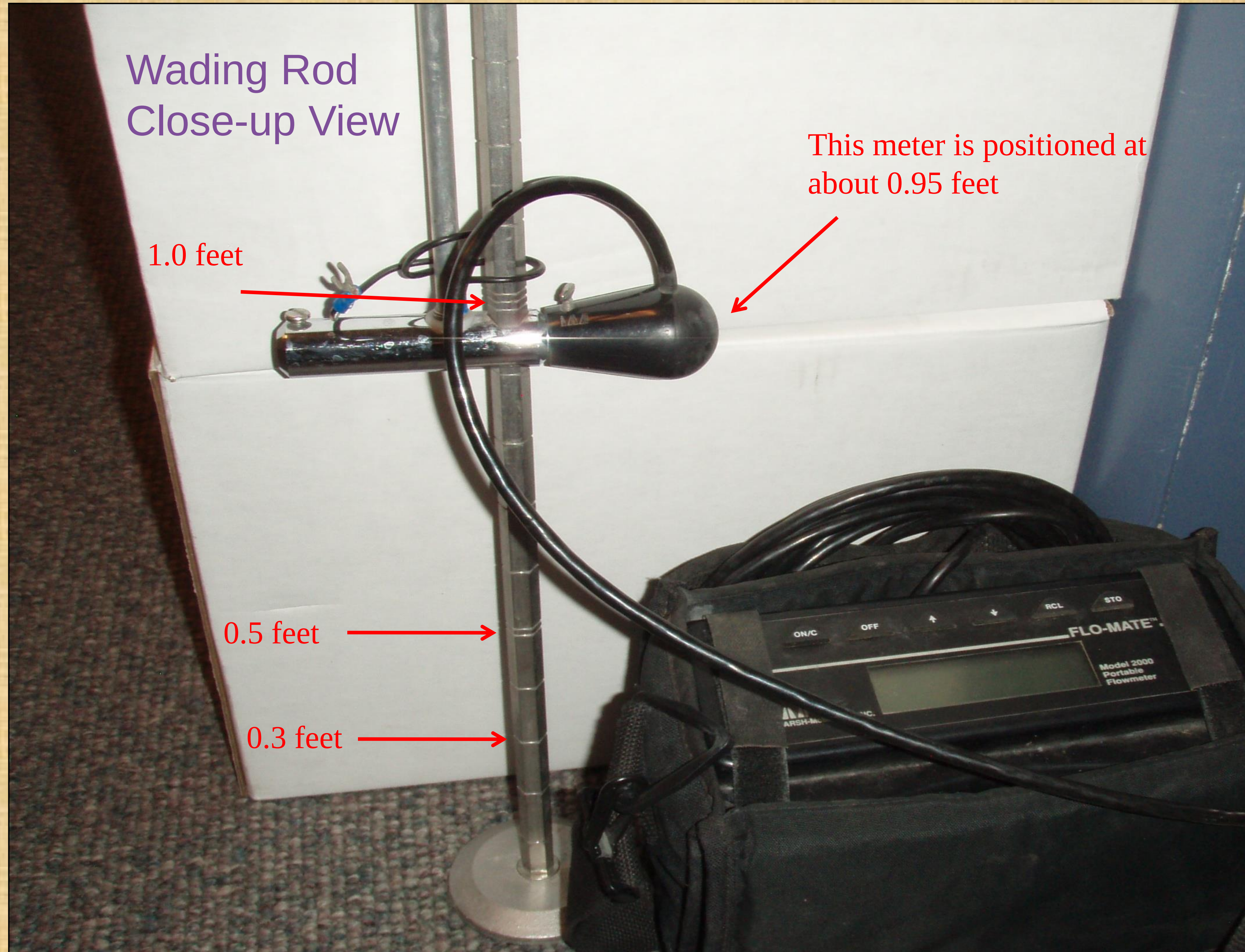
- Velocity-Area principle used to compute discharge

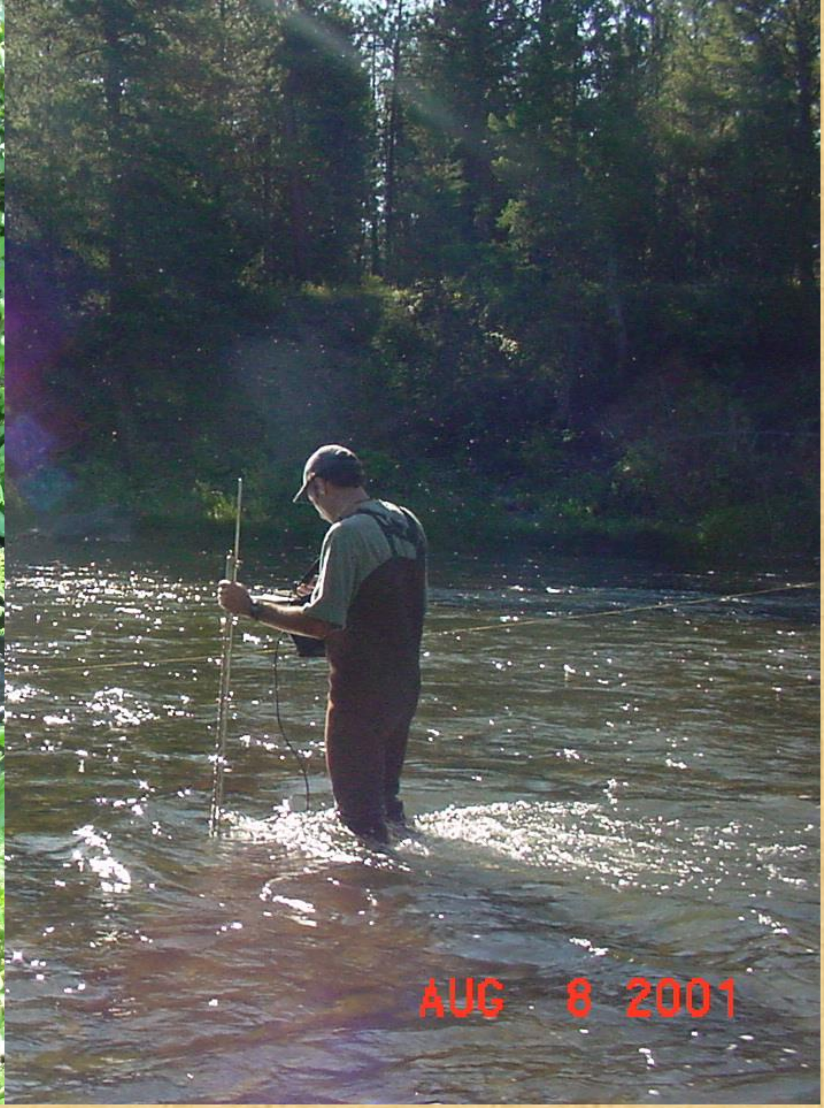
$$Q = A \cdot V$$

Total discharge is a summation of the partial discharges in measurement sections

$$Q_{Total} = A_1 \cdot V_1 + A_2 \cdot V_2 + \ldots + A_n \cdot V_n$$




Wading Rod
Close-up View
This meter is positioned at
about 0.95 feet
1.0 feet
0.5 feet
0.3 feet
ON/C
OFF
RCL
STO
FLO-MATE™
Model 2000
Portable
Flowmeter

Technique: Hold rod perpendicular to channel bottom
Hold instrument parallel to current
Stand behind and to the side of probe
Wear a cool hat

Current Meters

Selection of cross section for conventional current metering

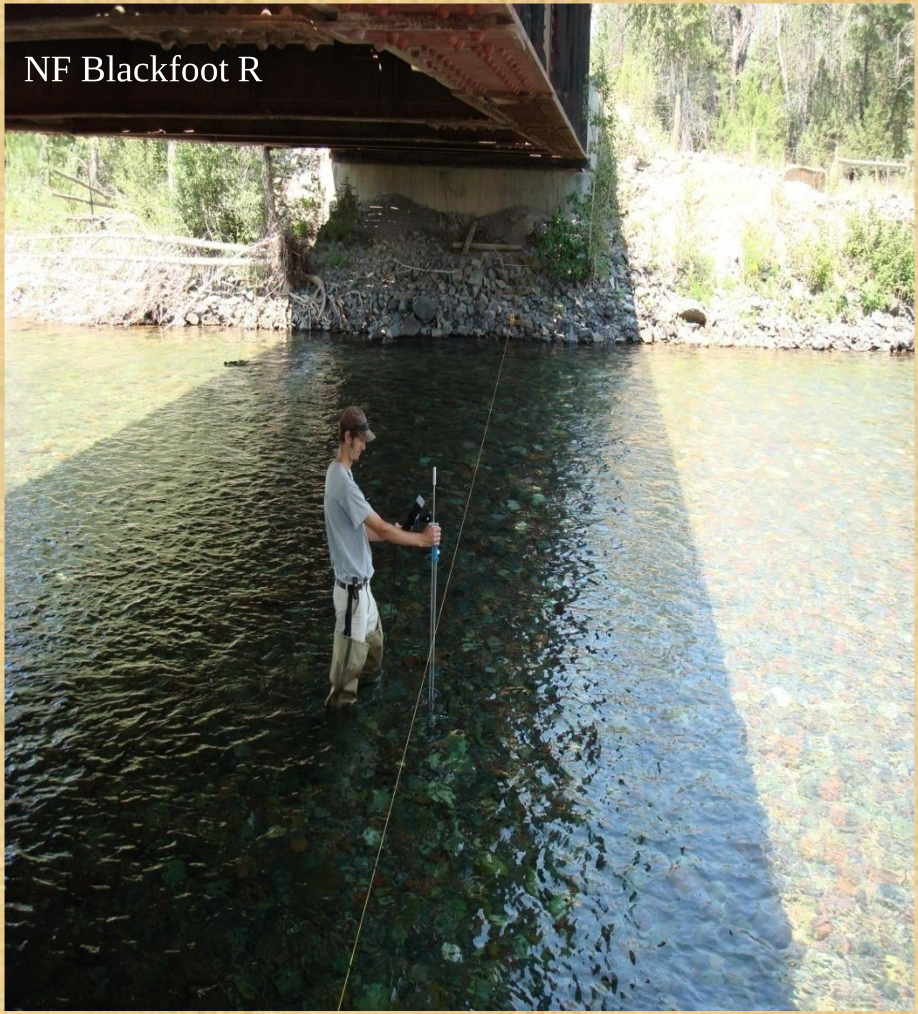
- Cross section should lie within a straight reach, where stream flow lines are parallel to each other
- Velocities should be greater than 0.25 ft/s and depths greater than 0.25 ft
- Streambed should be relatively uniform and free of numerous boulders and heavy aquatic growth

Current Meters

Selection of cross section for conventional current metering (cont)

- Flow in cross section should be relatively uniform and free of eddies, slack water, and excessive turbulence
- Measurement section should be relatively close to the gaging station; there should be no tributary inflows or water diversions between the measurement section and the gage

Site Selection - Q



Good cross-section

Bad cross-section

Sometimes you have no choice

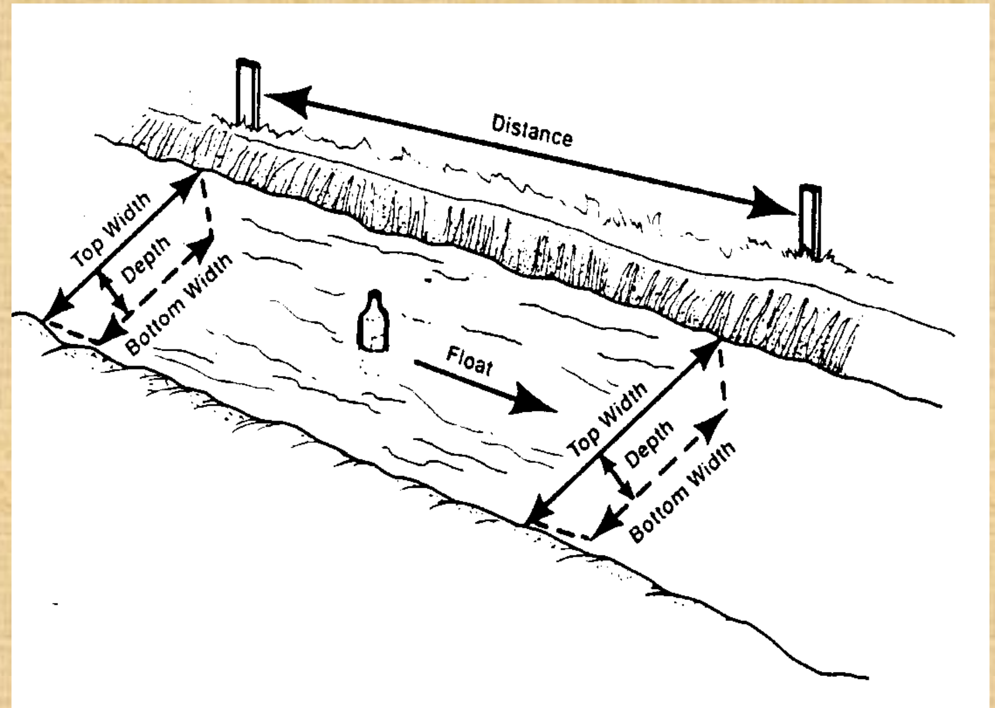
Float-Area Method

- Advantages
  - Useful when elaborate methods not warranted (ballpark assessment)
  - Useful for demonstrating flow-area concept
  - Recognized by DNRC as estimation in water right physical availability analysis

- Disadvantages
  - difficulty in determining average cross section
  - susceptible to wind currents, surface disturbances, and cross currents
  - least accurate of all other methods, not applicable for enforcement
  - Susceptible to criticism in a legal proceeding.

Float-Area Method

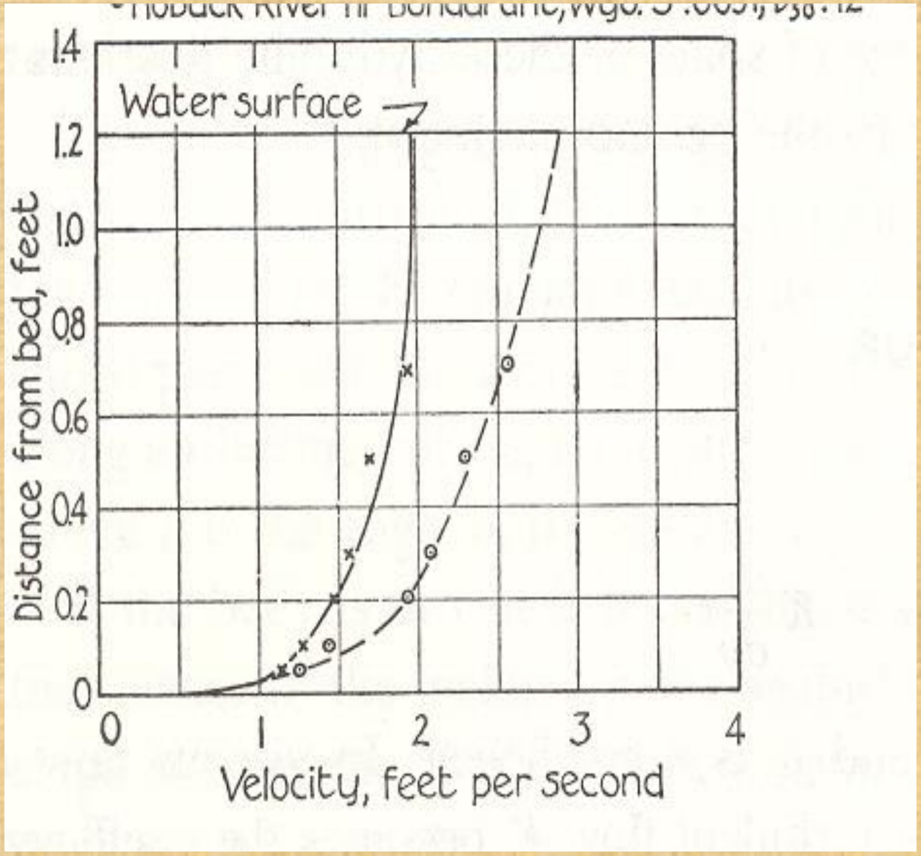
- Utilizes Basic Flow Equation to determine discharge
  - $Q = A_{average} \cdot V_{average}$



Float-Area Method

Coefficients for Converting Float Velocity to Water Velocity

Average Depth (ft)	Coefficient
1	0.66
2	0.68
3	0.70
4	0.72
5	0.74
6	0.76
9	0.77
12	0.78
15	0.79
20 and above	0.80



___water commissioner (experienced) ___water commissioner (new this year) other___________

1) Assuming the priority dates are the same, which purpose of use gets delivered first?

stock irrigation municipal instream flow for fisheries all at the same time

2) An irrigator is using a junior water right that is not in your District Court decree ahead of senior users that are in your decree. What course of action can you take to ensure water is properly diverted in priority?

3) An irrigator has a water right for 10 cfs out of Willow Creek. By the time water travels down a leaky ditch to their field, only 5 cfs remains. What is the maximum amount of water you, as water commissioner, can divert from Willow Creek?

4) A 2' parshall flume reads 1.64'. How much water is this equal to in cfs? In miner inches?

5) Name two things you would check when assessing the proper functioning of a flume or weir in the field?

6) What course of action would you take as a water commissioner if a water user's measuring device is not properly functioning?


Downtown Billings
N 27th Exit
1132 Shilo Rd
Shiloh Conservation Area

Water Supply Organizations

Irrigation Districts

Quasi-governmental organizations authorized by Montana District Courts. Many are associated with USBR Projects. Ex. Helena Valley Irrigation District, Bitterroot Irrigation District, Daly Ditches Irrigation District

Water Users Associations

Associated with State Water projects. Ex. Broadwater-Missouri Water Users Assn, Deadmans Basin Water Users Assn

Ditch or Canal Companies

Privately held. Ex. Dearborn Canal and Water Co.